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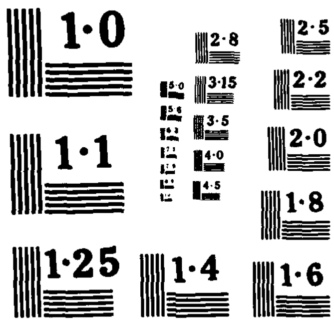

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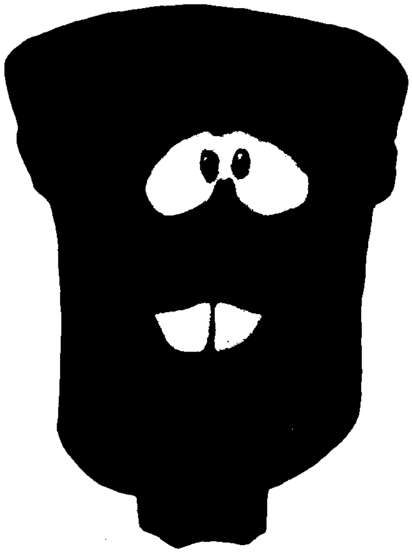
STEAM TRAP USERS' GUIDE

KEEP YOUR TRAP SHUT



STEAM LEAKS WASTE ENERGY $$$...

April 1985

UG-0005

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FOREWORD

Steam traps are an important element in the efficient operation of a steam system and in energy conservation. The high cost of producing and delivering steam mandates an effective steam trap inspection and maintenance program at all applicable naval activities. A comprehensive program for steam trap inspection and maintenance will pay for itself many times over in the cost of steam that would otherwise be wasted by neglected traps.

This Guide provides the basics in steam trap operation, selection and installation, inspection and troubleshooting, and repair and testing. Most important, though, it provides guidance and practical assistant in establishing an inspection and maintenance program. Implementation of such a program for steam traps would be a significant step in energy conservation and better use of utility operation funds.

The Users' Guide is useful as a handbook for individual study or for group training.

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CHAPTER 1. STEAM TRAPS

A steam trap is a compact, relatively low cost, automatic system for releasing condensate and noncondensable gases, and preventing the escape of live steam from a distribution system. It is an important element in efficient utility operations and in energy conservation. Good trapping can save very significant sums of money. Conversely, poor trap installations and neglected traps can waste steam costing many times the price of new traps and an effective inspection and maintenance program. In comparison with most plant equipment, steam traps are small, inexpensive, and relatively short-lived. Consequently, they are often ignored. Considering the cost of energy, and the role of steam traps in its utilization or waste, your continued attention is warranted.

Normally, the public works utilities organization will inspect and maintain exterior steam distribution traps and, probably, those in central boiler plants, while the maintenance organization will inspect and maintain steam traps installed with equipment in buildings. With consideration to this dual responsibility, the program described in this Guide can be effectively implemented and centralized.

This Users' Guide covers:

- The basic designs and operations of the more commonly used steam traps.
- Introductory guidance on trap selection, sizing, and installation.
- The economic benefits and elements involved in establishment of a steam trap inspection and maintenance program.
- Inspection schedules, methods, troubleshooting, and records.
- Shop repair and testing of steam traps.

1.1 Steam Trap Classification

Steam traps must function to allow steam to provide heat where required. Distribution lines and most heat transfer equipment must have steam traps. The trap allows air to be removed and eliminates condensate as soon as possible for greatest effectiveness of the line and heat transfer surface. All steam traps do not function in the same manner, but each trap operates using basic physical laws. There are three major classifications of steam traps whose functions are sometimes mixed to provide combination type steam traps.

a. **Mechanical** - operates using the difference in density between condensate and steam.

b. **Thermostatic** - uses temperature differences to discharge condensate and air.

c. **Thermodynamic** - operates using kinetic energy differences between flowing steam and condensate.

1.2 Steam Trap Types

There exists within each classification basic variations which are fairly widely used and have a broadly accepted, descriptive names. These are:

a. Mechanical

- inverted bucket trap
- float trap

b. Thermostatic

- bimetallic trap
- thermal expansion (i.e., wax, plastic, or liquid)
- bellows trap (usually filled with water or water-alcohol mixture)
- float and thermostatic (F&T) trap (this is the only combination function trap which has universal recognition as a "type" of trap)

c. Thermodynamic

- orifice plate trap (the orifice plate may not be regarded by some as a true thermodynamic trap)
- piston impulse trap
- disk trap

1.2.1 Mechanical Traps. Mechanical traps work because steam travels above the greater density condensate flowing along the bottom of any container holding both fluids. As more condensate collects, it raises the liquid condensate level. A mechanism which reacts to the rising level will allow the condensate to be discharged. As the condensate is discharged, the liquid level drops and the discharge path closes. The simplest mechanism that will move with a rising level of condensate is a closed float. The float can be attached to a lever which controls the opening and closing of a valve. Condensate is discharged due to the higher pressure upstream than downstream of the valve. If there is greater pressure downstream than up, condensate will build up flooding the heat-transfer surfaces. That area of the heat exchanger is then not available for heat transfer.

a. Inverted Bucket Trap (Figure 1-1, external). An inverted bucket trap can be thought of as an opened soup can turned upside down floating on the surface of a pool of water. When the contents of the bucket are mostly air, the bucket floats. When there is little air and mostly condensate captured within the bucket, the bucket sinks and allows a valve to discharge the condensate. When filled with steam, the bucket floats and keeps the valve shut. There is condensate all around the bucket bottom, sides, and top. If there is no condensate in the body of the trap to seal the bottom of the bucket, steam can flow around the dropped bucket and through the open valve at the top (see Figure 1-1, operational cutaway). Inverted bucket traps can be primed at startup by the condensate in the system. To insure priming, keep the discharge valve closed until the bucket floats, unless that is done automatically. Liquid entry to the inverted bucket is at the bottom of the bucket no matter whether the inlet and outlet are in line, on the sides, or on the bottom and

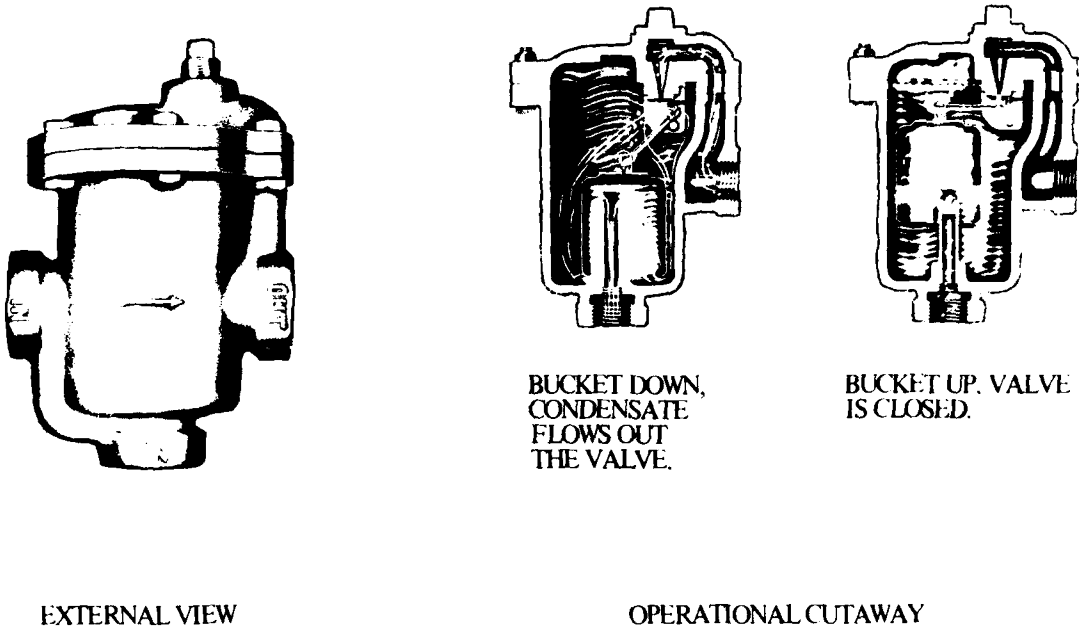
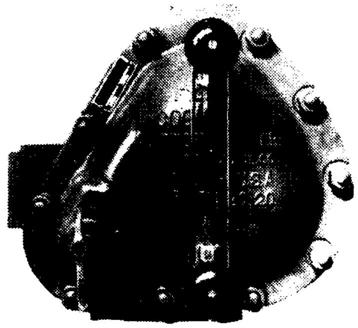


Figure 1-1. Inverted Bucket Trap.

top. Inverted bucket steam traps have different sized outlet ports to correspond to the pressure difference across the trap. As the pressure difference increases, the area of the outlet port must be decreased to balance the increased pressure difference. A trap sized for a large pressure drop (small outlet port) will work at lower pressures but will have lower capacity. A trap sized for a small pressure drop (large outlet port) installed in a higher pressure application will not open even when full of condensate. Inverted bucket steam traps must have a vent in the top of the bucket to allow air to leak out of the bucket into the condensate above and around the bucket. On the next sinking of the bucket, the air is discharged along with some condensate. If the air could not leak out from the bucket, the bucket would fill with air. Since air is much lighter than condensate, the bucket would float. When the bucket floats, the valve is closed and the system "airbinds." The term "air" is the simplest way of talking about the gases in the steam system. This air contains noncondensable gases, such as carbon dioxide, nitrogen, oxygen, etc. Carbon dioxide can form carbonic acid which attacks ferrous materials. This is another reason why steam traps should remove air and condensate as soon as they form. Normal failure may be either open or closed.

b. Float Trap (Figure 1-2). Floats are normally sealed balls. As the level of condensate in the trap rises, the float is raised opening a valve. The float itself may cover the valve opening, or it may be attached through a



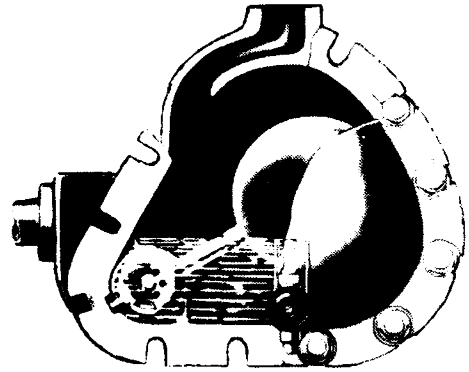
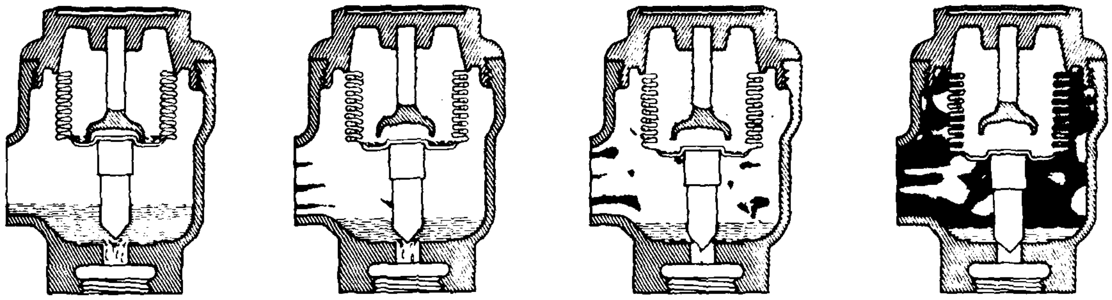


Figure 1-2. Float Trap.

pivoting lever arm to the valve. Maximum operating pressure and condensate flow rate must be known to select the proper size float trap. If the operating conditions are not known, the difference in pressure across the trap and valve size may prevent the float from rising, thus preventing release of condensate from the trap. Float traps normally fail closed.

1.2.2 Thermostatic Traps. The term "thermostatic" means heat in balance. Since steam contains more heat energy than condensate, its heat can be used to control steam trap operation. See Figure 1-3 for the operation of a thermostatic steam trap. Thermostatic traps are excellent for removal of air or noncondensable gases especially during startup. One type of thermostatic trap uses two types of metals, thus it is called a bimetallic trap. Another type uses a bellows filled with a liquid (usually water or a water-alcohol mixture). It is called a bellows trap (see Figure 1-5). Some type of thermal expansion element such as a wax, a plastic, or a liquid is used in another type of steam trap (called the thermal expansion steam trap).

a. Bimetallic Trap (Figure 1-4). The operation of a bimetallic steam trap is based on a bimetallic element which changes shape with changes in temperature. Bimetallic element movement controls a valve which releases air and condensate. The basic bimetallic trap is only sensitive to changes in temperature and needs to be adjusted to the pressure range (on the saturated steam temperature-pressure curve) in which it will be operating. To prevent the loss of live steam, or a buildup of condensate, manufacturers use several different valve and bimetallic element shapes and sizes. These designs allow the bimetallic steam trap to respond better to changes in its operating conditions. Bimetallic steam traps normally fail closed.



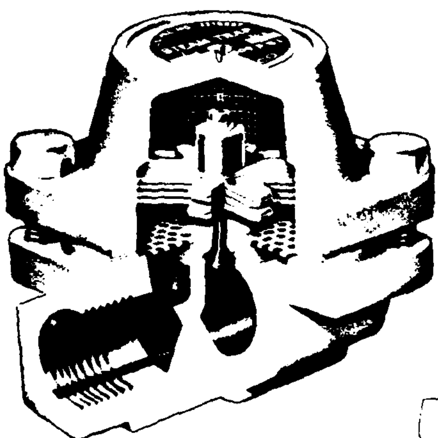
COLD BELLOWS ALLOWS AIR AND CONDENSATE TO ESCAPE.

BELLOWS EXPANDS AS STEAM ENTERS THE TRAP.

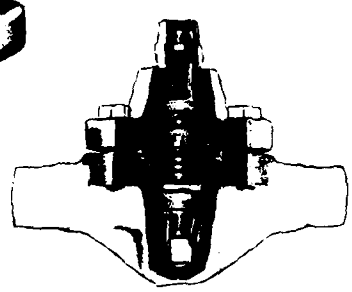
CONDENSATE CONTINUES TO FLOW OUT AS BELLOWS NEARS STEAM TEMPERATURE.

STEAM INCREASES BELLOWS TEMPERATURE; BELLOWS EXPANDS CLOSING VALVE.

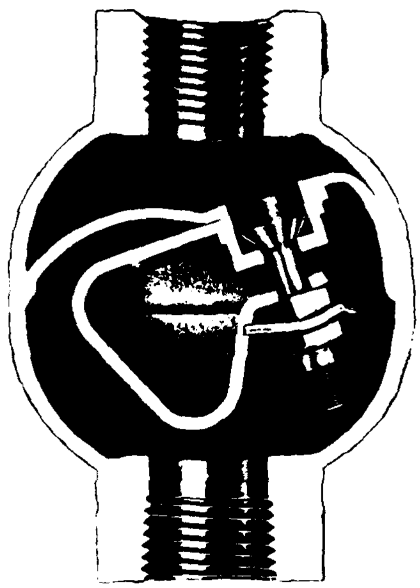
Figure 1-3. Thermostatic Trap Operation.



EXTERNAL - CUTAWAY SHOWING STACKED BIMETALLIC ELEMENTS OF VARYING LENGTHS



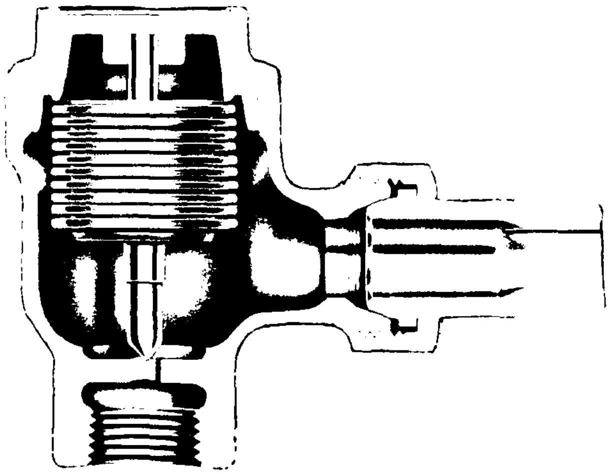
CUTAWAY SHOWING EXTERNALLY ADJUSTABLE BIMETALLIC TRAP



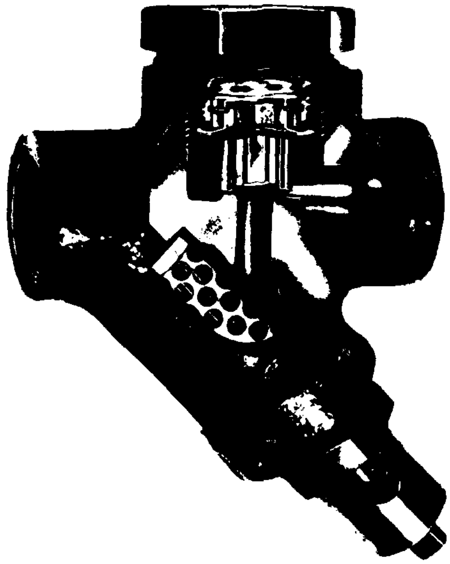
CUTAWAY SHOWING DELTA SHAPED BIMETALLIC ELEMENT AND 3-STAGE VALVE

Figure 1-4. Bimetallic Trap.

b. **Liquid Filled Bellows or Diaphragm Trap** (Figure 1-5). The more common design for low pressure heating systems is the bellows or diaphragm trap. The bellows element has many corrugations and may be filled with a liquid, such as alcohol, water, or a mixture of both. When heated by steam around the bellows, the liquid inside the bellows begins to vaporize. This forces the bellows to expand until the pressure inside is equal to the pressure outside the bellows (balanced pressure). Bellows can be used at varying pressures because when there is steam in the trap body outside the bellows, there is steam within the bellows. When there is condensate in the body, depending upon its pressure and temperature, there may be condensate or steam within the bellows. Bellows action is a combination of temperature and pressure since lower pressures allow water to boil at lower temperature. Diaphragm capsules are similar in action to bellows.



BELLOWS: CUTAWAY

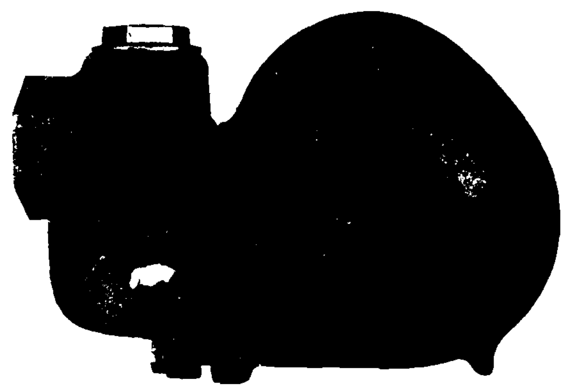


DIAPHRAGM: EXTERNAL CUTAWAY

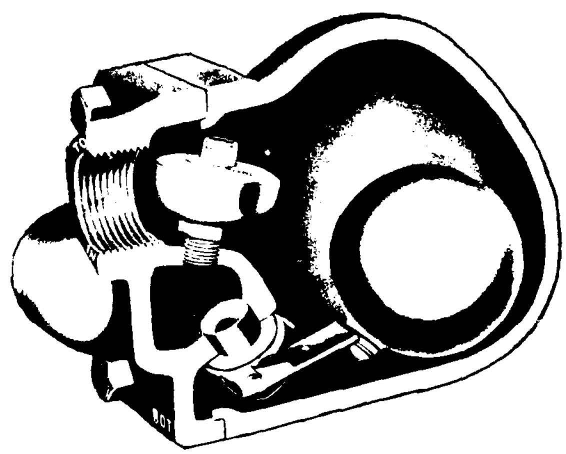
Figure 1-5. Bellows and Diaphragm Traps.

If a bellows trap is taken apart while hot, the bellows may continue to expand and destroy itself. If a bellows trap is exposed to superheated water, the fill will completely vaporize, achieving much greater pressure inside the bellows than it is designed for causing the bellows element to distort or rupture. If bellows are subjected to water hammer, their corrugations flatten from a semicircle to a sharp crease which will cause failure. When a bellows breaks, it loses its vacuum and expands. This pushes the valve into the seat stopping any condensate flow. Bellows steam traps normally fail closed.

c. **Float and Thermostatic Trap** (Figure 1-6). The most widely used float and thermostatic (F&T) traps have a ball float attached to a lever which pivots. The pivoting action causes the valve on the inlet side to open and close. All float and thermostatic traps must be installed so that the float drops when there is no condensate and rises when condensate collects. The most common feature of a float and thermostatic trap is that it is bulky. The size allows space for the float to rise and fall, usually pivoting. The two parts that show on the outside are the body and cover. Both are usually made of steel or cast iron bolted together with at least four bolts. A gasket seals the mating surfaces. The thermostatic element is usually a bellows or diaphragm but can be a bimetallic arrangement. The thermostatic element must be high in the trap to respond to steam which is lighter than water. The thermostatic portion of the trap is usually not affected by condensate but stays closed when steam, and open when air, is present. See Figure 1-7 for operation. The thermostatic element may have a separate cover for ease of testing, examination, and removal, or it may be accessible only upon opening the cover



EXTERNAL



INTERNAL

Figure 1-6. Float and Thermostatic (F&T) Trap.

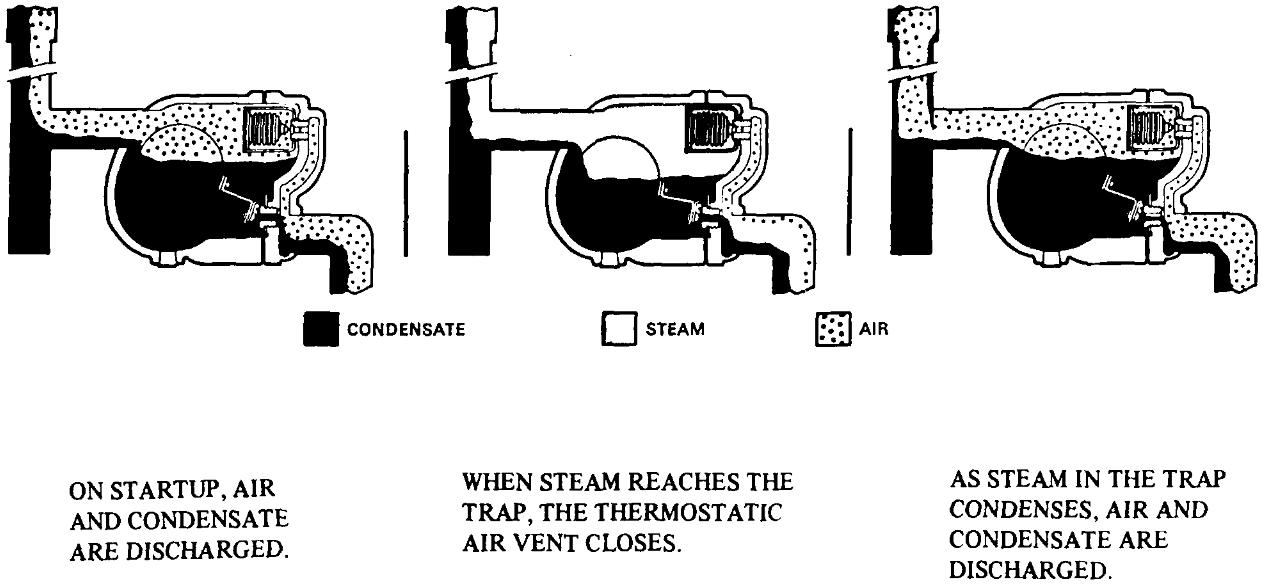


Figure 1-7. Operation of a Float and Thermostatic Trap.

of the main body. There are a few manufacturers who build floats which are free-floating (no mechanism to operate a valve in and out of a seat). One trap design has two hemispherical half shells made of different thickness of stainless steel so that no matter how the condensate sloshes, the heavier shell will be at the bottom. The outlet of these free-floating balls is at the bottom. When there is condensate in the body, the ball floats allowing the condensate to pass through the seal to the return system. When there is no condensate, the ball settles down on the seat, sealing against steam leakage. Steam will not float the ball due to its weight. Some free-floating ball traps have a separate thermostatic element at the top to release air and some manufacturers build guided floats which are cylindrical and hollow down the vertical center. A solid rod then is positioned so that the float always moves around the rod when there is a changing amount of condensate. The seat is sealed by an extension at the bottom of the vertical float which acts as a valve plug. The turning of the ball or cylinder causes a varying position of valve and seat for uniform wear.

The upstream side of the trap can have a lower pressure than the downstream side if the steam valve is modulated closed. Therefore, some manufacturers install vacuum breakers on the top of their float and thermostatic traps to allow atmospheric pressure into the body of the trap. They state that any vapor lock can then be broken, allowing the positive pressure to cause condensate flow through the trap to its discharge. This prevents flooding of the heat exchange equipment. Float and thermostatic steam traps normally fail closed.

d. Thermal Expansion Steam Trap (Figure 1-8). The thermal expansion type steam trap operates over a specific temperature range without regard to changes in pressure. The thermal element may be a wax, a plastic, or some sort of special liquid. This thermal element is used because it has a high expansion rate when subjected to a small increase in temperature. The thermal element is sealed off from direct contact with the condensate and steam.

When condensate is flowing through the trap the valve would be fully open. With a slight rise in temperature up to the saturation temperature, the thermal element would dramatically expand closing the valve and preventing loss of live steam. Almost any operating pressure can be selected over which to open and close the valve by selecting the corresponding saturation temperature at which the thermal element will dramatically expand. Thermal expansion steam traps normally fail open.

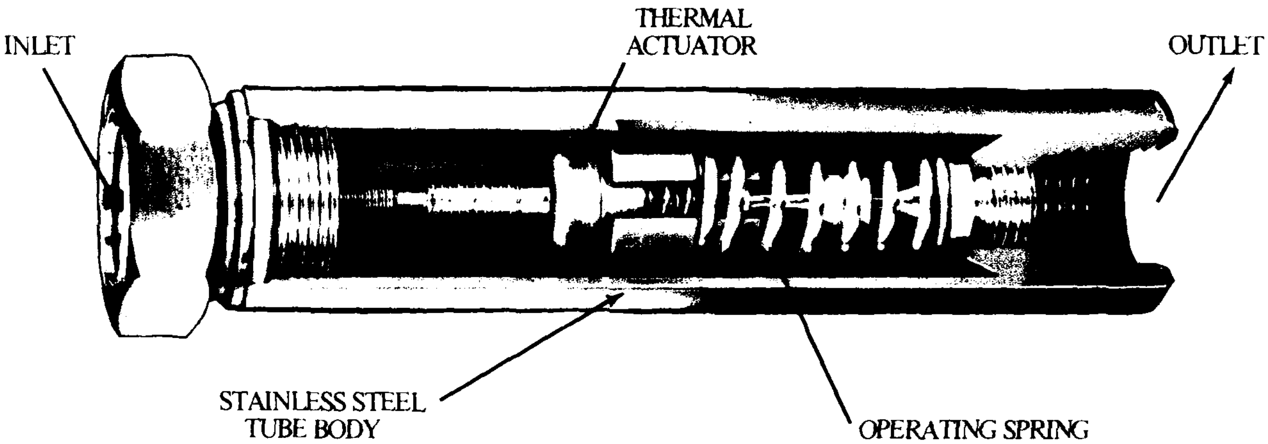
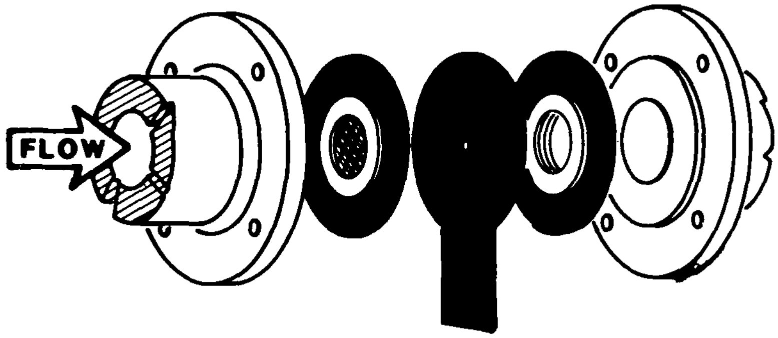


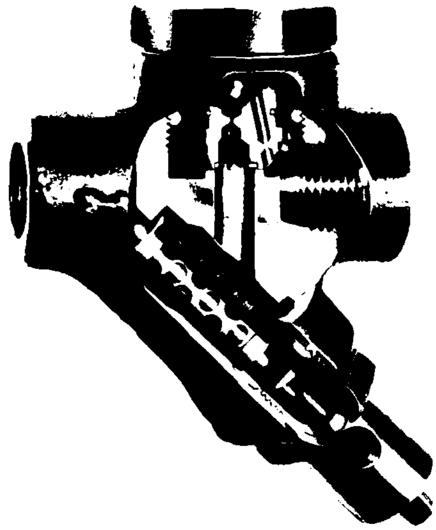
Figure 1-8. Thermal Expansion Steam Trap.

1.2.3 Thermodynamic Traps. Thermodynamic steam traps operate using the differences in the flow energy, velocity, and pressure of steam and condensate. The velocity of steam flowing through an orifice will be much greater than that of condensate. Thermodynamic steam trap designs also take into account the difference in the pressure drop between steam and condensate flowing through an orifice or a venturi.

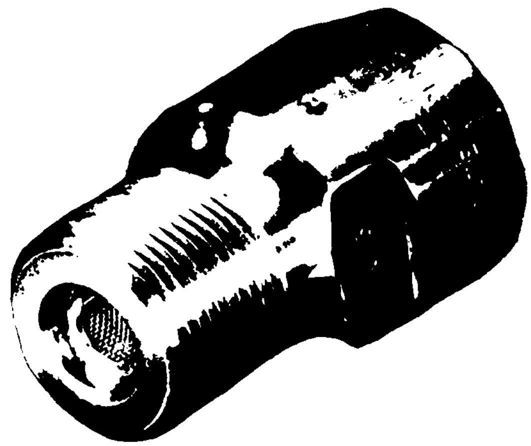
a. Orifice Trap (Figure 1-9). When a gas or vapor passes through a restriction, it expands to a lower pressure beyond the restriction. Drilling a small hole in a plate (called an orifice plate) or placing a short section of pipe between two sections of pipe (called a venturi) is the equivalent of slightly opening a valve. An orifice trap operates on the *principal of continuously* removing condensate from the steam line. This continual condensate removal allows the orifice trap to use a smaller diameter outlet than other types of steam traps which operate an open-close-open-close cycle. Thus,



EXPLODED PARTS DIAGRAM
SHOWING ORIFICE PLATE



EXTERNAL-CUTAWAY
SHOWING VENTURI



EXTERNAL
ORIFICE WITH NOZZLE

Figure 1-9. Orifice Traps.

the potential loss of live steam during system startup, or when the trap has failed open, is less for an orifice trap than for other types of steam traps. Also, the mass flow rate of steam is much less than that of condensate, cutting down the potential loss of live steam during normal operation. Since they are always open, the mode of failure of an orifice trap would be to clog with debris, or for the opening to corrode to a much larger opening.

c. **Piston Impulse Trap** (Figure 1-10). The first thermodynamic operating trap was the piston impulse style. The piston impulse style valve lifts to expose a relatively large seat area for cool condensate. As the condensate heats up and approaches steam temperature, some flows by the piston

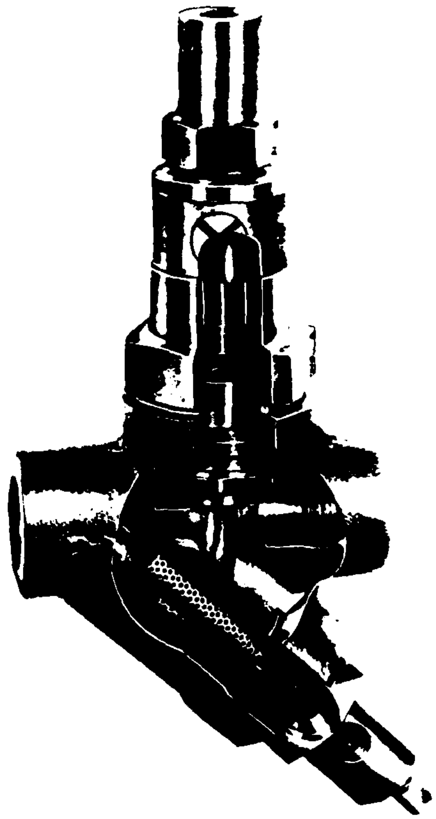
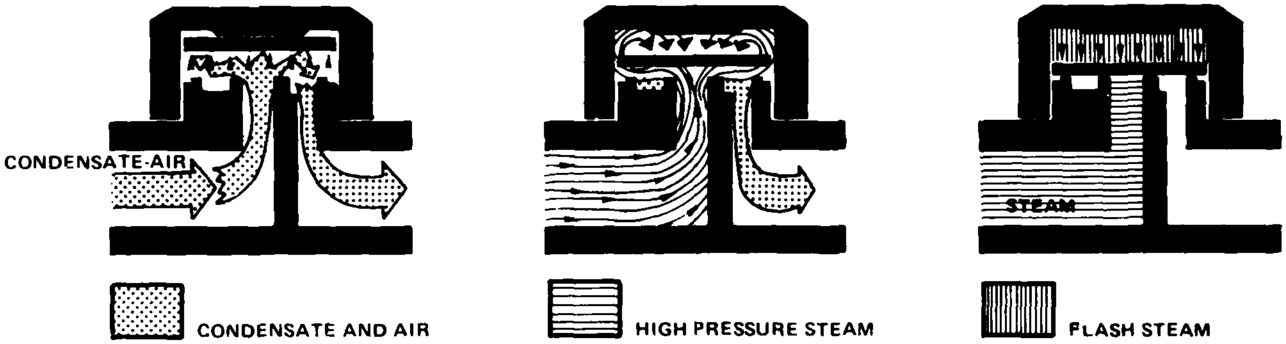


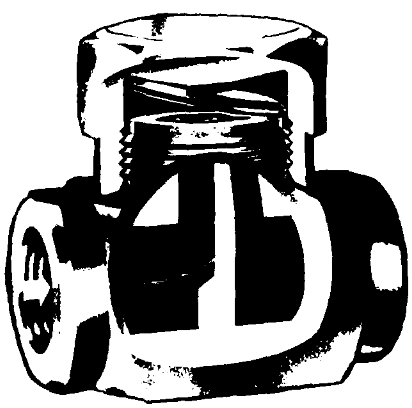
Figure 1-10. Piston Impulse Trap (External-Cutaway).

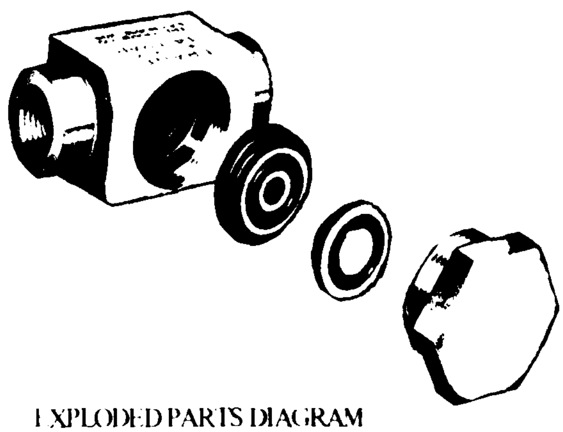
opening around a disk on the piston valve and flashes into steam. The flash steam at a pressure between inlet and discharge is pushing against a relatively large flange area on top of the disk and tends to push the valve down and closed. Steam in the flash or control chamber tends to prevent any more steam from entering the trap until it condenses. Once closed, the trap will not open until steam in the control chamber cools and condenses and incoming condensate blocks steam from flowing into the control chamber. When the steam in the control chamber condenses, the pressure above the piston drops allowing the valve to open. Air or noncondensable gas flows out the center vent hole in the piston. If blocked by dirt, the trap becomes air-bound and nonfunctioning. Normal trap failure may be open or closed.

d. Disk Trap (Figure 1-11). The disk thermodynamic trap has only one moving part, the disk. Just as with the piston impulse trap, there is a chamber above the disk which can hold steam or flashing condensate. The intermediate pressure over the entire area of the top of the disk (between the inlet and outlet) pushes the disk toward the seat closing the orifice. The opposing force is the pressure of the inlet steam against its inlet orifice. When there is steam at the trap, the disk snaps shut against its seat. As the steam in the control chamber condenses, and/or leaks under the seat, there is less force to keep the disk closed and it snaps open. A disk trap's air handling capability is dependent upon the individual manufacturer's design and machining care. Disk traps are adversely affected by back pressure because of lower closing forces than other steam trap designs. Disk traps normally fail open.



OPERATION





EXPLODED PARTS DIAGRAM

EXTERNAL - CUTAWAY

Figure 1-11. Disk Trap.

CHAPTER 2. STEAM TRAP SELECTION, SIZING AND INSTALLATION

Steam traps must be the right type, the correct size, in the best location, and properly installed to efficiently serve the system and to achieve maximum service life. The wrong type of trap can reduce the efficiency of a piece of steam-using equipment by as much as 35 percent. Properly selected, sized, and installed traps are the best guarantee for efficient operation, long service life, and minimum downtime.

The establishment and implementation of standards for trap type, size, and installation are important steps in the overall utility operation and energy conservation programs. Many steam trap applications are similar and standards can be set for groupings of traps for like conditions. As traps are replaced, the standards can be implemented by installing the type and size trap engineered for the particular application. Over time the system will be brought to the standards.

In one petrochemical plant with an inventory of over 9000 traps, the dedication of a plant engineer paid large dividends. At the start there were 38 different types/sizes of traps in use, and consumption was 42 pounds of steam per pound of product. After conducting a baseline survey (see paragraph 3.2.1), he established a set of steam trap standards and implemented a formal inspection and maintenance program. In a little over 2 years, there were four basic types of traps in use, with only a few exceptions for unique applications, and the steam usage was down to 23 pounds per pound of product. It was estimated that energy savings were $3 for every $1 spent on the program.

2.1 Selecting the Type of Trap

The major considerations in selecting the type of steam trap are:

a. Type of service

- continuous or intermittent removal of condensate
- temperature of the condensate (related to system pressure)
- range of load on the trap
- rate of change of the load

b. Operational

- normal steam loss during operation
- reliability
- failure mode most likely to occur

- water hammer potential

- danger of freezing

c. **Economic**

- initial cost

- ease of installation and removal

- ease of inspection and diagnosis

- life expectancy of the trap

Experience with the particular system and equipment and knowledge of site specific conditions are the most important elements in trap selection. Manufacturer's recommendations are also useful, but vary considerably. Table 2-1 contains a compilation of several guidelines for selection of the proper type of trap. Table 2-2 provides a summary of key operating characteristics of the types of traps used most frequently. Additional guidance extracted from NAVFAC Design Manual (DM) 3.8 and Federal Specification WW-T-696 is provided in the following paragraphs.

2.1.1 Design Considerations. DM-3.8, Exterior Distribution of Utility Steam,... provides the following guidance applicable to the selection of steam traps:

a. The float trap action is controlled by the condensate level in a float chamber and can be used to lift condensate.

b. The thermostatic trap may be used to automatically vent air and non-condensibles from large coils. It may be used with unit heaters, radiators, and convectors where the condensate flow is gravity-controlled from the trap. The results of misuse of this trap are trap chatter or trap failure to remain closed. This type of trap shall not be used as a "lift trap;" i.e., where condensate must be lifted to a higher elevation.

c. The float and thermostatic trap may be used in most heating applications where air must be vented and the condensate main is above the trap. Two trap functions are contained in one housing: a thermostatic vent trap and a high capacity float trap for condensate removal.

d. Inverted bucket traps are used on low pressure systems, particularly with blast coils or unit heaters. The discharge from this type of trap is intermittent and requires a definite pressure differential.

e. The various impulse and thermodynamic traps depend upon the difference in specific volume of steam and water to limit flow through a fixed size orifice for flow control. These traps do not work well in a system where the condensate can back against the operating mechanism of the trap and open it when there is no condensate flow from the upstream side. These traps are particularly useful for steam tracing of pipe lines where there will be some flow at all times.

Table 2-1. Steam Trap Selection Guide.

APPLICATION	SPECIAL CONSIDERATIONS	PRIMARY CHOICE (Note)	ALTERNATE CHOICE
Steam Mains and Branch Lines	o Energy conservation o Response to slugs of condensate o Ability to handle dirt o Variable load response o Ability to vent gases o Failure mode (open)	Inverted bucket Thermostatic in locations where freezing may occur.	Float and Thermostatic
Steam Separators	o Energy conservation o Variable load response o Response to slugs of condensate o Ability to vent gases o Ability to handle dirt o Failure mode (open)	Inverted bucket (large vent)	Float and Thermostatic Thermostatic (above 125 psig)
Unit Heaters and Air Handling Units	o Energy conservation o Resistance to wear o Resistance to hydraulic shock o Ability to purge system o Ability to handle dirt	Inverted bucket (constant pressure) Float and Thermostatic (variable pressure)	Float and Thermostatic (constant pressure) Thermodynamic (variable pressure)
Finned Radiation and Pipe Coils	o Energy conservation o Resistance to wear o Resistance to hydraulic shock o Ability to purge system o Ability to handle dirt	Thermostatic (constant pressure) Float and Thermostatic (variable pressure)	Thermostatic
Tracer Lines	o Method of operation o Energy conservation o Resistance to wear o Variable load performance o Resistance to freezing o Ability to handle dirt o Back pressure performance	Thermostatic	Thermostatic
Shell and Tube Heat Exchangers	o Back pressure performance o Gas venting o Failure mode (open) o Resistance to wear o Resistance to hydraulic shock o Ability to purge system o Ability to handle dirt o Ability to vent gases at low pressures o Energy conservation	Inverted bucket with large vent (constant pressure) Float and Thermostatic (variable pressure)	Thermostatic

NOTE: Thermostatic traps should be used in any application where freezing temperatures may occur.

Table 2-1. Steam Trap Selection Guide (Continued).

APPLICATION	SPECIAL CONSIDERATIONS	PRIMARY CHOICE	ALTERNATE CHOICE
Process Air Heaters	o Energy conservation o Ability to vent gases o Ability to purge system o Operation against back pressure o Response to slugs of condensate o Method of operation	Inverted bucket	Float and Thermostatic Thermodynamic
Steam Kettles:			
Gravity Drain	o Energy conservation o Resistance to wear o Resistance to hydraulic shock o Ability to purge system o Ability to handle dirt	Inverted bucket	Thermostatic
Siphon Drain	o Energy conservation o Resistance to hyraulic shock o Ability to vent air at low pressures o Ability to handle air start-up loads o Ability to handle dirt o Ability to purge system o Ability to handle flash steam	Thermostatic	

Table 2-2. Steam Trap Operating Characteristics.

CHARACTERISTICS	BELLOWS THERMOSTATIC	BIMETALLIC THERMOSTATIC	DISK	F&T	INVERTED BUCKET
o Method of operation (discharge)	continuous (1)	semi-modulating	intermittent	continuous	intermittent
o Operates against back pressure	excellent	poor	poor	excellent	excellent
o Venting capability	excellent	excellent	good (3)	excellent	fair
o Load change response	good	fair	poor to good	excellent	good
o Handles dirt	fair to good	good	poor	poor to good	excellent
o Freeze resistance	excellent	excellent	good	poor	poor (5)
o Waterhammer resistance	poor	excellent	excellent	poor	excellent
o Handles start-up loads	excellent	fair	poor	excellent	fair
o Suitable for superheat	yes	yes	yes	no	no
o Condensate subcooling	5-30 degrees F	50-100 degrees F	steam temperature	steam temperature	steam temperature
o Usual failure mode	closed (2)	open	open (4)	closed	open

1. Can be intermittent on low loads.
2. Can fail open due to wear.
3. Not recommended for very low pressure.
4. Can fail closed due to dirt.
5. May be insulated for excellent resistance.

2.1.2 Trap Limitations. Federal Specification WW-T-696 covers a number of the more commonly used steam traps. The following limitations are provided for consideration when selecting the type of trap to use:

a. Bucket trap

- Trap will not operate where a continuous water seal cannot be maintained.
- Must be protected from freezing.
- Air handled capacity not as great as other type traps.

b. Ball float trap

- Must be protected from freezing.
- Operation of some models may be affected by water hammer.

c. Disk trap

- Not suitable for pressures below 10 psi.
- Not recommended for back pressures greater than 50 percent of inlet pressure.
- Freeze proof when installed as recommended by manufacturer.

d. Impulse or orifice trap

- Not recommended for systems having back pressure greater than 50 percent of the inlet pressure.
- Not recommended where subcooling condensate 30°F below the saturated steam pressure is not permitted.

e. Thermostatic trap

- Limited to applications in which condensate can be held back and subcooled before being discharged.
- Operation of some models may be affected by water hammer.
- Diaphragm and bellows types are limited to applications of 300 psi and 425°F maximum.

f. Combination float and thermostatic trap

- Cannot be used on superheated steam systems.
- Must be protected from freezing.
- Operation of some models may be affected by water hammer.

2.2 Sizing Traps

Factors that affect the accuracy of trap sizing are: (1) the unavoidably large range in condensate load for many steam services, (2) the wide variance in operating pressure and differential pressure, and (3) the uncertainty of trap capacity because of error in estimating condensate temperature. Sizing errors can offset most of the system savings provided by trapping. Traps that are too small cause condensate to back up. Oversized traps allow live steam through. Along with selection of the proper type of trap, correct sizing is the important step in establishing trapping standards for your system. In setting up standards, a review of past practices against current results may avoid repeating errors in sizing.

Determining the correct size trap requires:

- Calculating or estimating the maximum condensate load.
- Determining the operating pressure differential and the maximum allowable pressure.
- Selecting a safety factor.
- Sizing the type of trap from manufacturers' capacity tables.

a. Condensate Load. The amount of condensate generated by items of equipment can generally be obtained from equipment manufacturer's literature. For most all applications, formulas, tables and graphs are available in steam trap manufacturers' brochures for calculation of condensate loads. Examples of simplified estimating aids are shown in Table 2-3.

b. Pressure Differential. One element in trap capacity is the difference in pressure between the supply line and condensate return. Of course, if the trap discharges to the atmosphere, the differential pressure will be the supply pressure. For sizing traps, the maximum steam operating pressure would be used. Frequently, traps are installed with the outlet connected to a return system which is under some pressure. The trap must operate against this pressure plus a static head if the trap is required to lift the condensate to a return at a higher level. Table 2-4 gives examples of the reduction in trap capacity caused by this back pressure which must be taken into account when sizing traps.

c. Safety Factor. The safety factor is a multiplier applied to the estimated condensate load since trap ratings are based on maximum discharge capacity; i.e., continuous flow ratings. Safety factors are provided in manufacturers' literature and are usually expressed in terms of the trap application. The safety factor may, also, be expressed for the type of trap used. Factors vary from 2:1 to 10:1 and are influenced by the operational characteristics of the trap, accuracy of the estimated condensate load, pressure conditions at the inlet and outlet, and the configuration of the installation design.

Table 2-3. Estimating Condensate Loads.

INSULATED STEAM MAIN

lb/hr of condensate per 100 LF at 70°F (at 0°F, multiply by 1.5)

Steam Pressure (psig)	Size of Main (inches) 2	4	6	8	10	12
10	6	12	16	20	24	30
30	10	18	25	32	40	46
60	13	22	32	41	51	58
125	17	30	44	55	68	80
300	25	46	64	83	103	122
600	37	68	95	124	154	182

GENERAL FORMULAS

Application	lb/hr of condensate
Heating Water	$= \frac{GPM}{2} \times$ temperature rise °F
Heating Fuel Oil	$= \frac{GPM}{4} \times$ temperature rise °F
Heating Air with steam coils	$= \frac{CFM}{900} \times$ temperature rise °F
Heating: pipe coils and radiation	$= \frac{A \times U \times \Delta T}{L}$

A = area of heating surface, ft^2
U = heat transfer coefficient (2 for free convection)
ΔT = steam temperature - air temperature, °F
L = latent heat of steam, BTU/lb

Table 2-4. Percentage Reduction in Steam Trap Capacity.

Inlet Pressure (psig)	Back Pressure (% of Inlet Pressure) 25%	50%	75%
10	5%	18%	36%
30	3%	12%	30%
100	0	10%	28%
200	0	5%	23%

If the condensate load and pressure conditions can be accurately determined, the safety factor used can be low which helps avoid oversizing. When experience with the steam system and equipment and thoughtful engineering of trap sizing are applied, safety factors in the range of 2:1 to 4:1 are adequate for all but the most unusual conditions. When sizing from manufacturers' capacity ratings, make sure the ratings are based on flow of condensate at actual temperatures rather than theoretical rates or cold water flow tests.

2.3 Installation Guidelines

The establishment of standards for steam traps in your system includes standards for optimum location and correct installation. While this Guide cannot cover design and installation standards for the myriad of system and equipment conditions, the following are some general guidelines that can be used in establishment of standards, training, and applied in system upgrade efforts.

a. One of the most important aspects of every steam trap installation is that traps should be installed so they may be easily and quickly removed for service or replacement. All traps should be installed with unions on either side of the trap spaced to a standard overall dimension. Upstream and downstream service valves should be provided. Typical piping arrangements are shown in Figure 2-1.

b. A test discharge with valve should be installed after the trap in return condensate systems.

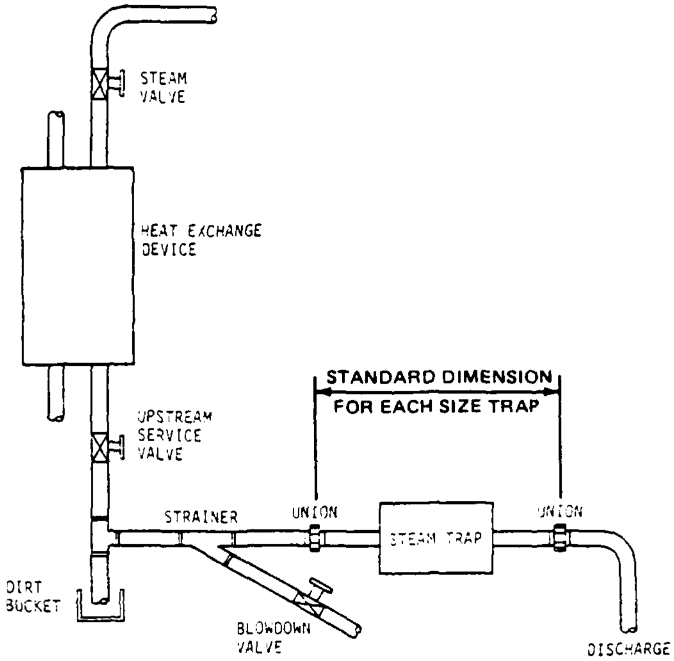
c. Inlet and outlet piping to a steam trap should be equal to or larger in size than the steam trap tappings. Each manufacturer specifies piping arrangements. The simplest styles have a single inlet and outlet, while others have multiple inlets and outlets. All unused inlet and outlet ports must be plugged. When using teflon tape thread sealant, at least one thread should be left exposed on the outside to ensure that tape is not cut off on the inside and carried into the trap.

d. A recent trend in trap design is the use of nonrepairable stainless steel construction. These traps are lighter, more compact, and have the same internal mechanism as the bolted styles. The use of cast iron traps is restricted to systems with a working pressure of 250 psig or less.

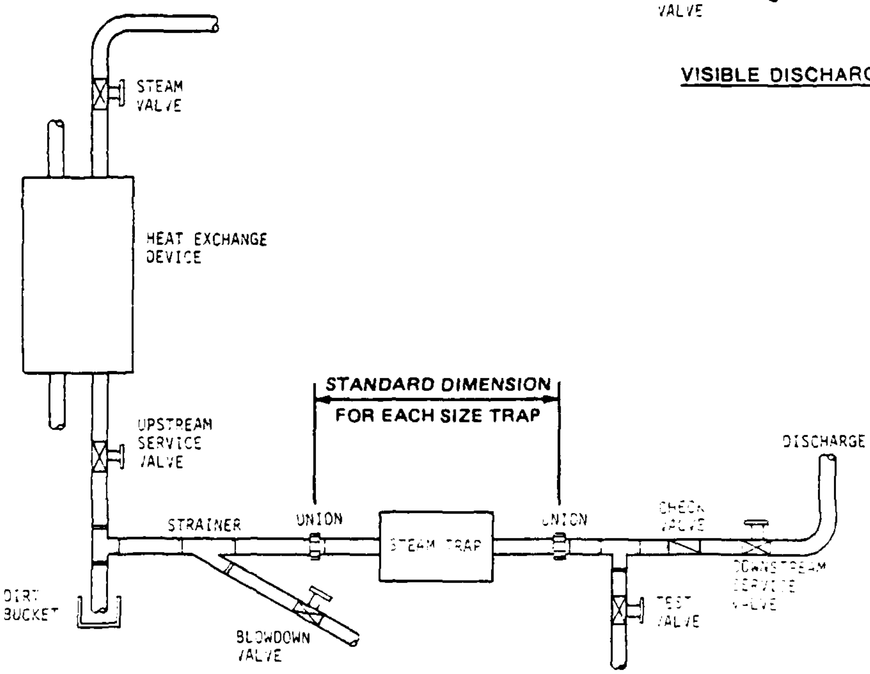
e. All lines should slope in the direction of flow. If not properly pitched, pockets of condensate may develop which contribute to water hammer. If the return line rises, a check valve should be installed on the discharge side of the trap. See Figure 2-1.

f. Traps are provided with permanent markings indicating the direction of flow. Float, thermostatic, and bucket traps depend on gravitational forces to operate properly and must be correctly oriented. Disk trap life may be doubled if they are installed horizontally so that gravity keeps the disk resting on its seat.

g. Occasionally, the upstream side of a trap may have a lower pressure than the downstream side if the steam valve is modulated closed. For this



VISIBLE DISCHARGE



INVISIBLE DISCHARGE

Figure 2-1. Typical Steam Trap Installations.

reason, some manufacturers install vacuum breakers on the top of their float and thermostatic traps to allow atmospheric pressure into the body of the trap. This permits any vapor lock to be broken, which in turn allows a positive pressure to cause a flow through the trap.

h. Float and thermostatic traps are widely used in low pressure heating systems. If they are properly installed below the steam space, they are effective in removing all of the condensate which forms. They are never made with less than 3/4-inch tappings and have been made with up to 3-inch tappings. Float and thermostatic traps may be used where there is a varying load so long as the maximum load does not exceed the trap's capacity.

i. Most float and thermostatic traps are rated somewhat artificially following a formula devised by the major manufacturers. As a consequence, a larger than normal safety factor is incorporated in the ratings shown in most catalogs.

j. Bimetallic traps are resistant to damage by water hammer and will allow unrestricted discharge of air on startup. The latest bimetallic steam trap designs allow condensate discharge near the saturation temperature over a specified pressure range with minimum loss of steam. These traps, however, do a poor job of handling air and noncondensables after startup.

k. The thermostatic trap's principal use is in comfort heating systems. It allows air and noncondensables to escape on startup. The fact that it does not always discharge condensate at saturation temperature is not a serious drawback in heating service. These traps are inexpensive for low pressure applications and are typically available in sizes from 1/2-inch to 2 inches.

l. Inverted bucket traps are especially suited to large or small capacity applications where water hammer may be a problem. Inverted bucket traps are subject to freezing in outdoor applications since they must retain a water seal in order to operate. Some inverted bucket traps may be effectively insulated with preformed, snap-on insulation that is removable and reusable. They have moderate air handling capability, very near that of float and thermostatic traps. Inverted bucket traps are recommended for unit heaters where there is no modulation of steam pressure. Strainers may be built into the bottom of inverted bucket traps to collect sediment. Inverted bucket traps are the most resistant of all traps to the effects of sediment.

m. Traps that are undersized for the pressure drop and condensate load will not effectively remove the condensate from the system. Traps that are not placed sufficiently below the system will also not drain properly. Traps without sufficient air handling capacity will lead to air blockage and prevent the proper operation of heating and other steam operated equipment. In general, steam traps should be located as close to the source of the condensate load as is practical.

n. Traps discharging into relatively high pressure areas may not always function properly. The flow may reverse and destroy weaker parts of the mechanism. Traps discharging into a return line higher than the trap level fall into this catagory.

o. Inverted bucket and float and thermostatic traps in outdoor installations may freeze when the steam is throttled and insufficient heat is available. No steam trap is freezeproof despite manufacturers' claims to the contrary.

p. Thermostatic and disk traps must give off heat in order to function properly and, therefore, must not be insulated. To ensure adequate opportunity for heat transfer, an 18 inch length of pipe adjacent to the traps inlet should also be uninsulated. Inverted bucket traps, however, do not need to lose heat in order to function and may be insulated as mentioned above.

q. Condensate from a high pressure steam system should not be introduced into the return lines of a lower pressure system unless these return lines are of adequate size. The higher pressure condensate tends to flash; i.e., expand into steam again, at the lower pressure and occupy much more volume than it did as condensate. This, in turn, prevents the traps associated with the low pressure system from operating properly. Water hammer may result from discharging high pressure condensate into a cooler low pressure return system.

r. There is no such thing as a "lifting" steam trap. Condensate will only be "lifted" to a return system if there is sufficient pressure difference to overcome the static head.

s. Balanced pressure thermostatic traps may be destroyed if there are long runs of pipe between the source of the condensate and the trap. See paragraph 1.2.2.b.

t. Bypass connections should not be used as a means of providing condensate removal even during short periods necessary for maintenance. A replacement trap should be installed. Bypass connections waste an enormous amount of energy even in very short periods of time.

2.4 Implementing Standards

Application of the selection criteria in paragraph 2.1 should result in a relatively few standard types for the great majority of trapping stations. Do not sacrifice efficient trapping solely for the sake of fewer types, but balance the standards against the advantages of easier maintenance and less inventory. Classify the types of traps selected by application, operating pressure, and condensate load. The standard types can be listed in a table showing these elements similar to Table 2-5.

As traps are sized, the type and size will merge in your plant standards. A sizing chart can then be developed around the types, pressures, and loads for use in sizing new installations.

A few standard installation schematics can be drawn that will apply to the majority of your trap installations. The goal is to reduce the number of variations and to portray the standards for continuing use by maintenance shops. Figure 2-1 provides an example.

Table 2-5. Example of a Standard Steam Trap Selection Table.

Application/ Operating Pressure	Condensate Load (lb/hr) 10	100	1000
Steam Mains:			
0-15			
0-150	(Enter types of traps selected as standard for your system)		
150-600			
Unit Heaters			
(etc.)			

All of these standards can usually be documented on one or two drawings including the trap type table, sizing chart and installation schematics. Keep it simple, make it accessible to all, and enforce use of the standards.

Appendix A contains a Steam Trap Product Guide published by the periodical Energy User News. It lists a cross section of traps available on the market.

CHAPTER 3. STEAM TRAP INSPECTION AND MAINTENANCE PROGRAM

As with all elements and components of utility systems, steam traps should have a structured, formal inspection and maintenance program to ensure steam system integrity, conserve energy, and save money. Traps are items of dynamic equipment subject to malfunction, corrosion, residue buildup, and wear. Operational and economic considerations demand a well planned and continuously executed program. The following paragraphs discuss the economic benefits of proper inspection and maintenance and the steps in setting up a program. It may prove beneficial to set the program up for exterior distribution systems first, to work out procedural problems, then extend it to include buildings.

3.1 Economic Benefits of Proper Inspection and Maintenance

Steam is expensive. The cost of fossil fuels will undoubtedly remain high, so production costs will not decrease. Aging physical plants demand increasing inspection and repair and an increasing share of the operation and maintenance dollars. Well planned and engineered steps must be taken to counter these influences on the cost of producing and delivering steam. The amount of steam lost by steam traps can be substantially reduced through routine inspection and maintenance that pays for itself in direct savings.

For example, a simple one-half inch thermodynamic disk trap can be as wasteful as a one-sixteenth inch hole in a 100 psig steam line and may lose approximately 13,300 pounds of steam per month. Similarly, a three-quarter inch bucket trap which fails in the open position on that same 100 psig steam supply line is equivalent to a steam loss of approximately 1,500 pounds per hour or one million pounds of steam lost per month. A one-quarter inch steam leak at 100 psig will waste 210,000 pounds per month. Table 3-1 illustrates the magnitude of steam and dollar losses in steam leaks for a pressure of 100 psig.

Table 3-1. Examples of Steam Loss for Various Orifice Sizes at 100 PSIG.

Orifice Size	Steam Loss Per Month (lb)	Cost Per month at $10/Mlb	Cost of Steam Loss Per Year
1/2"	835,000	$8,350	$100,200
3/8"	470,000	7,700	56,400
1/4"	210,000	2,100	25,200
1/8"	52,500	525	6,300

The prevention of steam loss through faulty steam traps is a direct, immediate utility operations savings. Of equal concern are the economic benefits of efficient heat transfer and prevention of steam system corrosion gained through proper operation of steam traps. As discussed in Chapter 1, the efficient removal of condensate, air, and CO_2 will aid in the following ways:

- Removal of air will help maintain higher temperatures.
- Removal of air by traps can improve heat transfer efficiency under certain conditions by up to 50%.
- Removal of condensate reduces water hammer, improves heat transfer, and provides more space for steam.
- Oxygen pitting and formation of corrosive carbonic acid are greatly reduced.

The economic comparison between losing steam on one hand, and repairing or replacing steam traps on the other, can be estimated. Similarly, a comparison of costs between a neglected system and continuous inspection and maintenance can be estimated. The following broad examples are based on generalized industry statistics. More complete comparisons can be made using your specific activity cost figures and experience.

a. **Replacing Old or Faulty Traps.** The cost of delivered steam at naval activities can range between $8 and $12 per 1,000 pounds (Mlb). Using $10 per Mlb in the one-half inch thermodynamic disk trap example above, lost steam would cost $133 per month. An average cost to replace the trap, including labor and material, may be approximately $200 to $250. Payback would be within two months.

The three-quarter inch bucket trap cited would be losing steam at a rate of $10,000 per month, as an extreme example, and replacement would pay for itself in one day.

With the high cost of producing and delivering steam, replacement or overhaul of failed steam traps provides significant economic benefits. Even for the larger traps in a normal system, with a nominal loss of steam, replacement payback would be measured in terms of a few months.

New traps, on the average, use about 2 lb/hr of steam in operation. As traps wear with age, this quantity increases at a rate of approximately 3 lb/hr per year until into the third year of the trap use. The steam used, in one sense wasted, by the average trap can then increase by as much as 8 lb/hr per year. Some guidance has been to replace or rebuild traps on a five-year cycle. By that time, the average trap may be using as much as 20 lb/hr even though continuing to operate.

At an average cost of $10 per Mlb, a five year old trap could be using:

$$20 \text{ lb/hr} \times 24 \text{ hrs} \times 365 \text{ days} \times \frac{\$10}{1000} = \$1750/\text{yr}$$

Replacement or overhaul in much less than 5 years is clearly economical, since an average trap can be purchased and installed for $200 to $250.

A study performed at the Naval Postgraduate School developed a guide for calculating the optimum time for trap replacement as:

$$\text{Time in service} = \sqrt{\frac{\text{cost of trap replacment (\$)}}{11.3 \times \text{cost of steam (\$/Mlb)}}}$$

For example, if a trap costs $250 to replace, and steam is costing $10 per Mlb to produce:

$$\text{Time} = \sqrt{\frac{\$250}{11.3 \text{ X } \$10}} = 1.5 \text{ years}$$

Of course, no activity needs to replace good operating traps every year and a half, but the increase in steam lost as a trap ages is a strong consideration in your replacement and trap rebuilding planning. This formula illustrates the point that a relatively small quantity of steam lost each hour can make frequent trap replacement economical. Replacement time depends a great deal upon the type of trap and its design.

b. Continuous Inspection and Maintenance. Industry experience shows that steam systems operating without a planned program have between 10 and 50 percent of the traps malfunctioning at any one time. A sample survey of your system can provide a statistical indication of the number of faulty traps for preliminary estimating purposes. Average steam losses can also be predicted. A general example of potential savings from a formal program is illustrated. Assume a 20 percent trap failure rate before the program is implemented, and 5 percent failure rate after the program is fully implemented.

Gross Savings = Steam loss before - steam loss after

Net Savings = Gross savings - cost of inspection/maintenance

Trap Failure Rate	Total Traps	Failed Traps	Average Leak Rate/trap	Cost of Lost Steam per Year
Before: 20%	500	100	15 lb/hr = 131,000 lb/yr	131 Mlb x $10/Mlb x 100 traps = $131,000
After: 5%	500	25	15 lb/hr = 131,100 lb/yr	131 Mlb x $10/Mlb x 25 traps = $32,750

Gross Savings = $131,000 - $32,750 = $98,250/yr

Cost of Program:

Inspection: Quarterly, 0.5 man-hours (mh)/trap = 1,000 mh/yr x $25/mh = $25,000/yr

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Maintenance: 50% of traps/yr = 250 traps x $50/trap = $12,500/yr

Net Savings = $98,250 - $37,500 = $60,760/yr

The examples above consider only the cost of steam lost from failed traps, which is fairly simple to estimate and price. The economic benefits of improved heat transfer and corrosion prevention cannot be readily quantified, but are no less real. In a system producing, say, 300 million pounds of steam per year at a total cost of $3 million, approximately 75 percent of the cost is fuel; a direct variable cost. A one percent improvement in the efficiency of the system could save over $20,000 a year in fuel cost alone. By all measures, a conscientious and well executed steam trap inspection and maintenance program pays for itself many times over.

3.2 Establishing an Inspection and Maintenance Program

The steps required to set up an effective program are:

a. **Baseline Survey.** The initial survey provides or verifies records of steam trap location and type, provides a steam trap map, determines the baseline condition of the trap inventory, and checks installation and use for misapplication.

b. **Establish System Standards.** Standards for types, sizes, and installation of traps eliminate misapplication, reduce inventory and system costs, and provide a basis for budgeting and trap replacement planning.

c. **Training.** As a formal program is established, the people involved in operation, inspection and maintenance, energy conservation, and engineering must be trained and indoctrinated in the goals of the program.

d. **Equipment.** Proper equipment for inspection will pay for itself in improved trap uptime and savings in manpower.

e. **Establish Inspection Schedules.** A balance between the cost of inspection and potential savings in operational costs must be achieved.

f. **Accurate Records.** Records that are easy to keep, which induce accurate entries, and support the program are a must.

g. **Improve Condition of the System.** A longer range, but integral, objective in establishing a formal program is to bring the condition of the steam traps to a level where inspection and maintenance are routine "moneymakers" rather than an uphill battle.

3.2.1 Baseline Survey. An effective program requires accurate knowledge of the steam trap inventory and its condition. The initial survey, to establish the baseline or to verify and augment existing records, should be a planned effort which results in:

- Location, type, and size of each trap.

- Function and sizing information (if available) for each trap to determine misapplications and sizing errors.

- Pressure at inlet and temperature at inlet and outlet.

- Activity wide steam trap maps.

- Current operating condition of each trap.

The survey planning can separate the activity into manageable segments by geographical area or by type of steam system/use. The system can be "mapped" more easily by segments and the separate areas will be useful in continuing inspection. The survey should locate traps hidden by equipment, insulation or other piping. Each trap should be assigned an identification number or symbol and tagged during the initial survey to facilitate future inspections and maintenance reports. The survey will provide information about existing conditions that may be used to estimate potential savings compared to maintenance and repair costs as discussed in paragraph 3.1.

A technique that can be productive is to establish and publicize a "hot line" telephone number for all base personnel to report steam leaks and suspected trap or system problems. Set this up at the beginning of the baseline survey and keep it as a part of the continuing inspection.

Steps to be taken in conducting the baseline survey are as follows:

- Divide the activity and/or steam systems into survey areas.

- Prepare steam trap maps for survey mark-up.

- Indoctrinate survey inspectors.

- Prepare survey forms. An example form is shown in Figure 3-1.

- Design trap identification system and prepare tags.

- Conduct the survey.

- Compile the data; analyze the results.

- Estimate number of failed traps, probable steam loss, cost of repair/replacement, and potential savings.

- Set goals for immediate inspections, near-term repair/replacement, and system upgrade.

3.2.2 System Standards. Standards for types and sizes of traps for given applications can minimize the potential for misapplication and usually reduce the number of different traps in the system. The inventory of replacement traps can, then, be reduced and maintenance procedures become more standardized. See Chapter 2 for a discussion of establishing the standards.

STEAM TRAP BASELINE SURVEY

DATE:______________ AREA/MAP NO.:________________________ INSPECTOR:__________________________

Trap Tag No.	Bldg/Grid Location	Type, Mfg, Model	Size	Location Description	Installation/ Service Description	O-Oper. F-Failed	Priority for Action/Remarks 1-Immed. 2-Schedule 3-Backlog

Figure 3-1. Example Baseline Survey Form.

3.2.3 Training. Even if you have people who are experts in steam traps, establishment of a formal inspection and maintenance program requires indoctrination of all concerned. This training begins with planning for the baseline survey. In addition to training utilities operation and maintenance personnel, those involved in engineering, planning and estimating, and procurement of steam traps should be familiar with the elements of the program. This manual can provide the basis for training. Typical topics for three types of indoctrination/training sessions are shown in Table 3-2.

Table 3-2. Inspection and Maintenance Program Training.

Type of Training	Topics Covered	Attendees
Overview of Program	• Program purpose, scope, and goals. • Records and data analysis • Continuing action • System upgrade plans • Role of each division	Engineering Planning Maintenance Control Budget and procurement Utility supervisors Maintenance supervisors
Program Management	• Establishing system standards • Trap selection • Replacement program • Monitoring the program • Record keeping • Estimating costs and savings	Engineering Planning Maintenance Control Utility supervisors Maintenance supervisors
Inspection	• System standards • Types of traps • Steam loss problems • Trap failures • Inspection methods and equipment • Troubleshooting techniques • Inspection records	Maintenance Control inspectors Utility supervisors Maintenance supervisors Operation and maintenance personnel

3.2.4 Equipment. Procurement of efficient and up-to-date equipment to assist inspectors is a necessary step in establishment of the program. See Chapter 4 for a discussion of inspection methods and uses of inspection equipment. The economics of steam losses through faulty traps are such that a few detections will easily pay for the cost of inspection equipment. Also, return on labor and training costs can be ensured by providing inspectors with proper equipment.

The two basic types of inspection equipment are sound detection and temperature measurement instruments. Available instruments range in sophistication and cost from a simple steel screwdriver to modern ultrasonic monitors

for sound and from simple heat sensitive markers to portable infrared equipment for temperature.

For temperature readings, the more costly and sophisticated instruments are hardly ever justifiable. Thermocouple thermometers with handheld digital reader are sufficient for most applications. See Chapter 4 for a discussion of inspection aided by temperature readings.

For inspection aided by listening devices, the more sophisticated ultrasonic instruments are recommended where the quantity of traps is sufficient for frequent utilization. Appendix B provides a list of representative manufacturers of sound detection equipment.

3.2.5 Inspection Schedules. The establishment of a formal program requires setting initial schedules for inspections to follow the baseline survey. When steam was cheap, it was good business to accept a certain level of steam loss, inoperative traps, etc. The lost steam cost less than the labor to correct the less serious problems. Today, steam costs ten to 15 times as much as it did only a few years ago, so it now pays to maintain the system at a much higher level. Inspections should be performed more frequently as the first step in raising the level of maintenance.

The frequency of steam trap inspections will be based upon the condition of the system, age of the traps, and percentage of traps found to be faulty in the baseline survey. Inspections will be more frequent for a neglected system and decrease as the system is brought up to standard. Each activity's schedule will depend upon local conditions and analysis of the baseline survey. As a general guide, until the percentage of failed traps is under 10 percent, inspect at least every two months. If the failure rate of traps is greater than 5 percent conduct quarterly inspections. As the failure rate is improved to below 5 percent, inspect biannually.

3.2.6 Records. Data obtained from the baseline survey (Figure 3-1) will provide the basic records for the steam trap inventory. As time and resources permit, additional data for individual traps should be acquired. Most of the information can be gathered during periodic inspections. In addition to the baseline survey data, the following inventory information will be useful for management of the program:

- date of installation
- orifice size
- end connection type
- end-to-end dimension (see Figure 2-1)
- insulation requirement

The inventory records must be updated whenever a trap is replaced.

The other type of required record covers inspection and repair. Periodic compilation and review of inspection reports will provide information on the

status and condition of steam traps as a whole and the affect the inspection and maintenance program is having. See Chapter 4 concerning inspection reports and records.

Most steam systems will contain enough traps to make simple automation of the inventory and records worthwhile. Once the baseline survey results are entered into an automated record, maintenance of the records with changes and periodic inspection reports will require less effort than a manual card or listing system. Retrieval, compilation, and review of the records will, accordingly, be economical.

3.2.7 Upgrade of the System. The goal of the inspection and maintenance program is to bring the steam trap inventory to a level where steam losses are negligible and system integrity is sound. Then, inspection and maintenance will be routine with a frequency that is not a burden. Accordingly, planning and execution of the program should include replacement of traps reaching their useful life and conversion to the standards established in accordance with Chapter 2. An extensive and aging system may require funding of repair projects to augment local maintenance funding in order to "catch up" with neglect of steam traps. As a minimum, an overt planned effort should be scheduled and budgeted to replace old traps and to implement correct standards of trap type and size.

CHAPTER 4. STEAM TRAP INSPECTION

The cost of steam lost through a leaking trap in one day can exceed the cost of a new trap. If a trap is not discharging condensate at its designed rate, the reduction in efficiency of the steam-using equipment can waste more money in one day than the cost of the trap. Good inspections that pinpoint problem traps for early repair or replacement are important. The following discuss inspection schedules, safety precautions, methods of inspection, trap failure, troubleshooting, and inspection reports and records.

While the trap is the focus of the inspection, external conditions of the trapping station should be inspected as well. Supports, bracing, insulation, external leaks, and corrosion should receive attention from the inspector during each trap inspection.

4.1 Inspection Schedules

As discussed in paragraph 3.2.5, continuing inspection frequencies will depend primarily on the condition of the system. The general guide is:

Trap Failure Rate	Inspection Frequency
over 10%	two months
5 - 10%	three months
less than 5%	six months

One manufacturer recommends inspection frequencies based on system pressure:

Pressure	Inspection Frequency
0 - 30 psi	annual
30 - 100	semiannual
100 - 250	quarterly or monthly
over 250	monthly or weekly

Exposed traps should be monitored daily during freezing weather. Also, traps serving critical process equipment should be monitored frequently.

Frequent inspections of the same equipment tend to become cursory in nature. More thorough, but less frequent, inspections are more effective. The primary goal, though, in scheduling inspections is to achieve a balance between the cost of inspection and steam loss and integrity of the system.

4.2 Safety Precautions

- Steam lines, traps, and steam equipment are HOT. Follow all safety rules for working where burns are potential.

- Wear protective clothing and safety gear (hardhat, goggles, gloves, etc.) when appropriate.

- Steam valves should be opened or closed only by authorized personnel.

- Always wire valve closed and tag DO NOT OPEN before working on or removing traps and strainers.

- Always isolate the steam trap from steam supply and pressurized return line before opening the trap for inspection or repair.

- Always isolate a strainer from pressurized system before opening.

- Never touch a steam trap with bare hands.

- For strainer blowdown, wear gloves and a face shield. Catch discharge in a bucket.

4.3 Inspection Methods

The basic methods of inspecting traps are visual observation, sound detection, and temperature measurements. Visual observation is the best and least costly method of checking trap operating condition, but none of the methods provide a cure-all for trap troubleshooting. Any one method can give misleading results under certain conditions. The best inspection is obtained by using a combination of two methods. Procedures for the three methods are covered below. The application of these methods in routine inspections and in trouble shooting traps that may be failing is covered in paragraphs 4.4 and 4.7.

4.3.1 Visual Observation. Observing the discharge from a trap is the only positive way of checking its operation. No special equipment is required, but training and experience are necessary, particularly for recognizing the difference between flash steam and live steam. See Figure 4-1.

- Flash steam is the lazy vapor formed when the hot condensate comes in contact with the atmosphere. Some of the condensate reevaporates into a white cloud appearing as steam mixed with the discharging hot water.

- Live steam is a higher temperature, higher velocity discharge and usually leaves the discharge pipe in a clear flow before it condenses to a visible cloud of steam in the atmosphere.

If the trap discharges to a closed condensate return system, it must have a valved test discharge pipe open to the atmosphere installed downstream of the trap.

A properly operating trap will discharge condensate and flash steam as it cycles. Some types of traps (inverted bucket, disk) have an intermittent discharge, some (float, F&T) should have a continuous condensate discharge, and some types (thermostatic) can be either. The presence of a continuous live steam discharge is a problem. The lack of any discharge flow, also, indicates trouble. See paragraph 4.7.

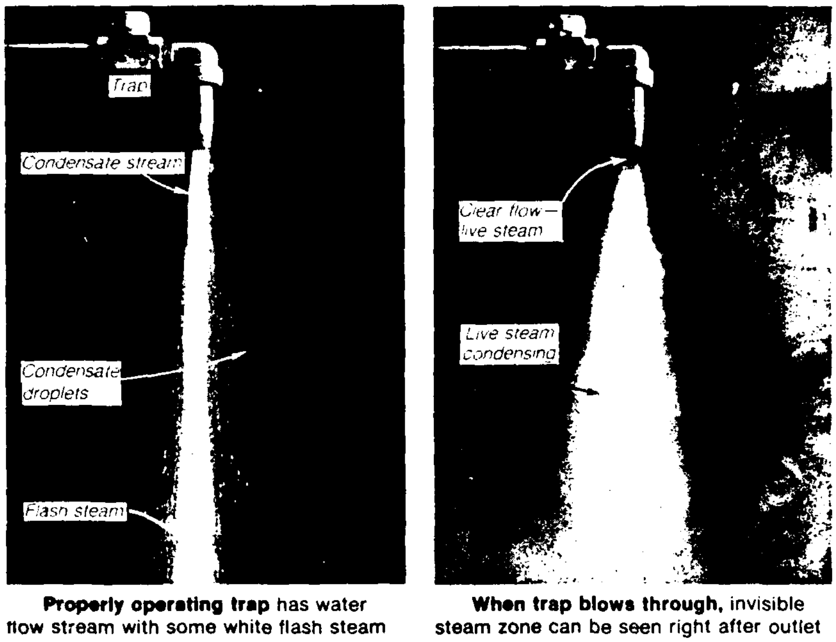

Figure 4-1. Illustration of Difference Between Flash Steam and Live Steam.

Inspectors should realize that when a trap is under a fairly heavy load the discharge will produce considerable flash steam. A faulty trap may be losing a significant amount of live steam that cannot be detected. In a condensate discharge of, say, 100 lb/hr a loss of 10 lb/hr of live steam will not be visually detectable. As discussed in paragraph 3.1, this relatively small loss can amount to the cost of a new trap in two to three months. Therefore, if a trap is suspected of being faulty, always check your visual inspection with another method.

A basic part of visual inspection is determining if the trap is cold or hot; at operating temperature. One method is to squirt water on the trap top and observe its reaction. The water will not react on a cold trap, but will bubble and bounce on a hot trap.

4.3.2 Sound Detection. Listening to traps operate, and judging performance and potential malfunction, is a convenient inspection method when working with a closed condensate return system. Experience is required, but much can be derived from the sounds made, or not made, by traps while operating.

By listening carefully to steam traps as they cycle, a judgment can be made whether they are operating properly or not. An inspector can hear the mechanisms working in disk, inverted bucket and piston traps. Modulating traps give only flow sounds which are hard to detect if the condensate load is low. However, the performance of a suspected trap should be crossed - checked visually or by temperature measurements since a trap that does not cycle may be either failed open or under a heavy condensate load.

Simple equipment can be effective such as industrial stethoscopes or a 2-foot length of 3/16 inch steel rod in a file handle. They are used simply by placing the probe end on the trap bonnet and your ear against the other end.

If you have a large number of traps, and situations where traps are congested or close to other equipment generating noise, ultrasonic listening equipment is warranted. These instruments have earphones, are equipped with probes, and allow selection of sound frequency bands. High frequencies are sensitive to flow noise, and mechanical sounds are detected at low frequencies.

4.3.3 Temperature Measurements. Diagnosing trap condition from temperature differences between upstream and downstream pipes is the least reliable inspection method. It can be useful in combination with visual or sound inspection as long as the potential ambiguities are recognized. As discussed in paragraph 3.2.4, equipment ranges from sophisticated infrared meters, to simple thermometers, to heat sensitive markers. A contact thermocouple thermometer is recommended.

File contact points on the pipe clean. Take temperature measurements immediately adjacent, and no more than 2 feet, on either side of the trap. The readings should be in the ranges shown in Table 4-1 for the pressures in the supply and discharge/return lines. Interpretation of the temperature readings requires knowledge of the line pressures. For example, a supply line at 150 psig with temperature of 340°F and a 15 psig return line with temperature of 230°F indicate a properly operating trap.

Table 4-1. Normal Pipe Temperatures at Various Operating Pressures.

Steam Pressure (psig)	Pipe Surface Temperature Range (°F)
0 (atmosphere)	212
15	225-238
30	245-260
100	305-320
150	330-350
200	350-370
450	415-435
600	435-465

4.4 Inspection Procedures

Before beginning routine periodic inspections, the trap inventory should be in good shape, steam trap maps of buildings and exterior areas should be prepared, and traps tagged for permanent identification with stainless steel tags.

Inspectors should be provided with efficient and convenient equipment. A suggested list follows and is illustrated in Figure 4-2.

- Carrying pouch and belt.
- Clipboard with trap lists and trap maps.
- Maintenance requirement tags (yellow and white).
- Valve wrench.
- Water squeeze bottle.
- Ultrasonic sound detector.
- Thermocouple thermometer.

Each activity will devise its own best methods for conducting inspections and identifying work required. Use of two different colored tags, as in the list above, is one method for identifying cold traps for investigation and failed or faulty traps for maintenance and repair.

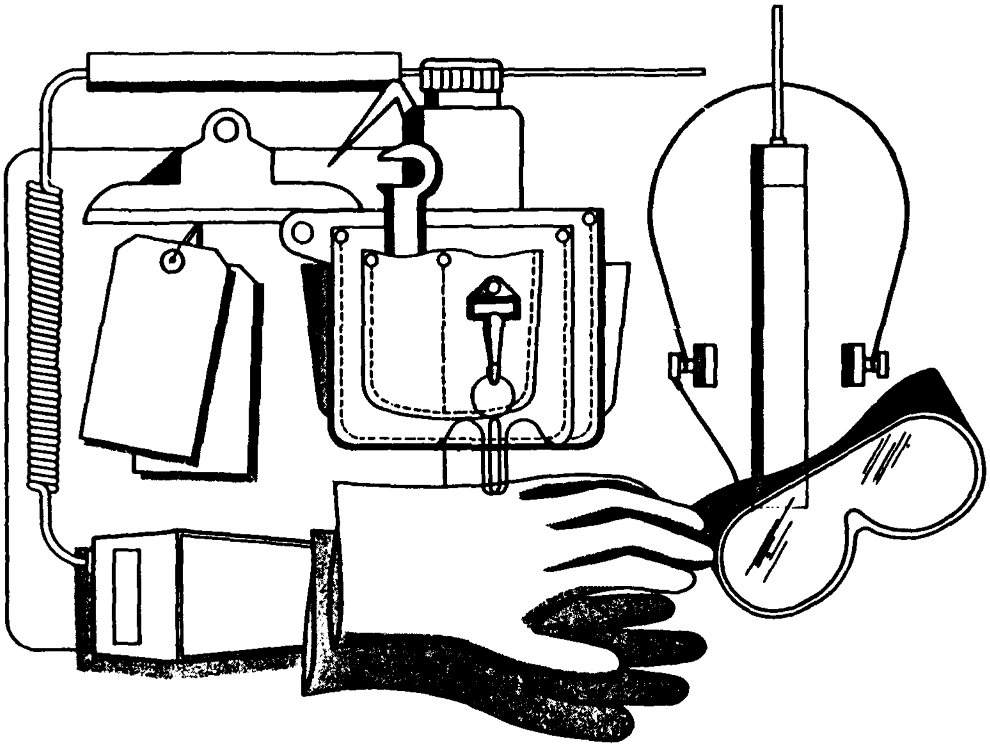

Figure 4-2. Steam Trap Inspection Equipment.

The following inspection checkoff list is a summary of steps for routine inspections applying the inspection methods outlined in paragraph 4.3. Paragraphs 4.5, 4.6, and 4.7, then, discuss problem areas inspectors should be trained in and able to identify during inspections.

STEAM TRAP INSPECTION CHECKOFF LIST

FOR ALL TRAPS:

- Is steam on?
- Is trap hot - at operating temperature?
- Wet test for signs of a hot trap. Squirt a few drops of water on trap. Water should start to vaporize immediately. If it does not, this indicates a cold trap.
- Tag cold traps with a yellow tag for maintenance check to determine if it is a system or trap problem.
- Blowdown strainer.

SOUND CHECK HOT TRAPS:

- Listen to trap operate.
- Check for continuous flow:
  - low pitch condensate flow
  - high pitch steam flow

- Check for intermittent flow.
- Is trap cycling?
- Note mechanical sounds.

VISUAL CHECK TRAPS THAT SOUND BAD:

- Close valve to return line.
- Open discharge valve.
- Observe discharge for:
  - normal condensate and flash steam
  - live steam
  - continuous or intermittent operation

TEMPERATURE CHECK IF NECESSARY:

- Clean spots upstream and downstream of trap for measuring temperature.
- Record supply line pressure.
- Measure supply line temperature.
- Record return line pressure.
- Measure return line temperature.
- Tag failed traps with white tag for replacement/shop repair.

CHECK EXTERNAL CONDITIONS:

- Supports and braces
- Insulation
- Corrosion
- Leaks

4.5 Inspection for Misapplication

Inspectors should be aware of and inspect for the following potential misapplications and installation problems:

- Trap installed backwards or upside down.
- Traps located too far away from the equipment being serviced. Piping runs too long.
- Traps not installed at low points or sufficiently below steam-using equipment to ensure proper drainage.
- Traps oversized for the conditions. Oversized traps allow live steam blow-through.
- More than one item of equipment served by one trap. "Group trapping" is likely to short circuit one item due to differences in pressure and other items will not be properly drained.
- The absence of check valves, strainers, and blowdown cocks where required for efficient operation.
- Trap vibration due to insecure mounting.
- Bypass line with valves open. If a bypass is necessary, it should be fitted with a standby trap.
- Condensate line elevation higher than steam pressure through trap can lift. No trap lifts condensate; the inlet steam pressure does.
- Inverted bucket and float and thermostatic traps, particularly, exposed to freezing temperatures.
- Thermostatic and disk traps which are insulated. These traps must give off heat to function.
- Disk trap with excessive backpressure, therefore, too low of a differential pressure for the trap to operate properly.

For trap location, check the ABCs:

- <u>A</u>ccessible for inspection and repair.
- <u>B</u>elow drip point whenever possible.
- <u>C</u>lose to the drip point.

4.6 Trap Failures

Traps generally fail in the closed or open position. By failing closed, there is a backup of air and condensate which floods the equipment and prevents

the equipment from performing its heat-transfer function. By failing open, air, condensate, and steam continue through the trap and into the condensate system thus wasting steam and affecting other heat transfer equipment by excessive pressures and temperatures in the return lines. Major causes of trap failure are residue buildup and wear.

a. Residue. Dirt, rust, and foreign particles can build up in steam traps quite readily, as the trap body forms a natural pocket for collection when the valve is closed. Dirt pockets should be installed on all steam header drip legs and the strainers should be opened periodically for blow down. Strainers, whether installed before the trap or included in the body of the trap, should have blowdown cocks installed to encourage cleaning. Installed, operating strainers are one of the most important protections for traps, but are only as good as their care. All strainers should be blown down every inspection. Figure 2-1 shows typical trap installations with strainers and blowdown valves.

Residue between the seat and disk may cause a trap to fail open and residue buildup in the trap body may cause a trap to fail closed.

Piston impulse traps, disk traps, and orifice traps should have a much finer mesh strainer due to their small holes.

b. Wear. Wear of internal parts, linkages, and seals will cause trap failures in both the open and closed positions. When the mating surfaces of valves and valve seats wear out, there is a tendency for an initial leak to enlarge by a process called "wire-drawing" which shows up as a small "gully" worn across the mating surfaces. Also, valves that are partially open because of residue lodged between the valve and seat can initiate wire-drawing, since steam will follow the condensate and cut the mating surfaces with its high speed.

Cast iron and steel traps are often subject to the valve seat becoming loose due to the erosive effect of flashing condensate. This results in leaks many times greater than a failed new trap.

Continuous operation and excessive use will cause links, levers, pins, pivots, and elements to change shape and malfunction due to wearing.

If trap failure persists and a comprehensive inspection indicates that the failure is not due to residue buildup or wear, the inspector may determine the problem to be actual system troubles rather than trap malfunction.

4.7 Troubleshooting

During periodic inspections, inspectors will have many traps to inspect within relatively short times. Fast identification of a faulty or failed trap is important. If the nature of the problem can also be identified, so much the better. Economical, cost effective inspection, though, depends on specifying the problem traps with the least expenditure of manpower. Correction of the problems can, then, be scheduled in a consolidated, planned, efficient manner by the shops.

Troubleshooting begins with the knowledge of trap operations (Chapter 1) and combines the methods of inspection with familiarity with trap misapplications and potential failures discussed in this chapter. Table 4-2 outlines the basic indicators of normal operations and problems for the various types of traps.

4.8 Inspection Reports and Records

An example inspection log is shown in Figure 4-3. This log is intended to report results of periodic inspections and is a temporary record. The log does not, in general, need to repeat data contained in the steam trap inventory record discussed in paragraph 3.2.6.

Permanent inspection and repair records are an important element in the inspection and maintenance program. The record provides information needed to identify chronic problem areas, develop life cycle costs, and generally aid in upgrading the steam system. The inspection reports would be transferred from the inspection log, as applicable, to the permanent record. The following data should be included in the permanent record:

- Trap identification and location
- Date initially installed
- Scheduled inspection frequency
- Date of last inspection
- Date and description of last repair

An alternative system that can be used if automation of the permanent trap records is not feasible is an index card system. Each trap has its own index card with identifying/inventory data entered. The card is carried by the inspector during period inspections and the result is entered. One index card may allow room, front and back, for 10-12 inspections. To be useful, the data must then be compiled manually from hundred or thousands of cards. This system is much less effective than the temporary inspection log with data being entered into a report generating system.

Table 4-2. Troubleshooting Steam Traps.

TYPE TRAP	NORMAL OPERATION	PROBLEM INDICATION	POSSIBLE CAUSE
		VISUAL INSPECTION	
ALL TYPES	o Trap hot under operating conditions. o Discharge mixture of condensate and flash steam. o Cycling open/close depending on type of trap. o Relatively high inlet temperature.	o Live steam discharge; little entrained liquid.	Failed open.
		o Condensate cool; little flash steam.	Holding back condensate.
		o No discharge.	Failed closed; clogged strainer; line obstruction.
		o Leaking steam at trap.	Faulty gasket.
		TEMPERATURE MEASUREMENT	
		o High temperature downstream	Failed open.
		o Low temperature upstream	Failed closed, clogged strainer, line obstruction.
FLOAT AND F & T	o Continuous discharge on normal loads. May be intermittent on light load.	SOUND INSPECTION o Noisy; high pitch sound.	Steam flowing through; failed open.
	o Constant low pitch sound of continuous flow.	o No sound.	Failed closed.
THERMOSTATIC	o Discharge continuous or intermittent depending on load, pressure, type. o Constant low pitch sound of continuous or modulating flow.	o Same as for float trap above.	
INVERTED BUCKET	o Cycling sound of bucket opening & closing.	o Steam blowing through.	Failed open.
		o No sound.	Failed closed.
	o Quiet steady bubbling on light load.	o Discharging steadily; no bucket sound.	Handling air; check again in hour.
		o Discharging steadily; bucket dancing.	Lost prime.
		o Discharging steadily; bucket dancing after priming.	Failure of internal parts.
		o Discharging steadily; no bucket sound.	Trap undersized.
DISK	o Intermittent discharge.	o Cycles faster than every 5 seconds.	Trap undersized or faulty.
	o Opening and snap-closing of disk about every 10 seconds.	o Disk chattering over 60 times/minute or no sound.	Failed open.

STEAM TRAP INSPECTION LOG

DATE: ________________ INSPECTOR: ________________

TRAP I.D.	LOCATION	OPERATING	INSPECTION REPORT	REPAIR PRIORITY

Figure 4-3. Example Inspection Log.

CHAPTER 5. SHOP REPAIR AND TESTING

Specific repair of the various types of steam traps is beyond the scope of this Users' Guide. The following general guidelines and shop testing set-up are, however, recommended.

5.1 Trap Repair and Replacement

Developing and implementing standard trap and piping configurations and dimensions will help avoid installation errors and reduce downtime. Inlet and discharge pipe sections, valves, strainer, trap, and unions for the more commonly used types and sizes can be made up and stored. When a trap requires shop repair, the replacement can be installed quickly. The repaired trap can be made up as a spare and kept in stock.

As an installation safety measure, different capacity traps may be configured with different end-to-end measurements to avoid installing a wrong size trap. See the example in Figure 2-1.

A repairable steam trap suspected of failure must first be disassembled to inspect the interior condition of the valve body as well as the internal working parts of the valve. Remove dirt, debris, and foreign matter from the trap to ensure the valve interior is clean. Inspect all mechanisms and linkages for damage, distortion, and freedom of movement.

Common reasons for trap failure or malfunction are listed in Table 5-1. Look for these items first. If field conditions permit, such as good access to the trap, space to work, and system downtime is acceptable, certain types of trap repairs may be performed with the trap installed. More often, though, it will be cost effective to replace the trap immediately and perform the overhaul in the shop.

Table 5-1. Common Steam Trap Malfunctions.

Type of Trap	Potential Malfunction
All types	Valve or seat worn, wire-drawn, clogged. Valve seat loose. Strainer damaged or deteriorated. Leaking gasket. Inlet or outlet plugged.
Thermostatic	Bellows distorted, cracked. Dirt clogged in bellows. Bimetallic element distorted. Improper element setting. Element failed or closed.

Table 5-1. Common Steam Trap Malfunctions (Continued).

Type of Trap	Potential Malfunction
Float or Float and Thermostatic	Float leaking or collapsed. Linkage worn or damaged. Leaking internal seals/gasket. Float not operating freely. For thermal element in F&T see above.
Inverted Bucket	Bucket cracked, not holding water seal. Trap body clogged with dirt. Mismatch of valve and valve seat. Linkage worn or damaged. Bucket vent plugged. Leaking internal seals.
Thermodynamic - disk - impulse - orifice	Disk worn, distorted, rusty, wire drawn. Seat worn, wire drawn. Bonnet worn or damaged. Orifices worn. Worn control cylinder or valve plug. Leaking internal seals.

5.2 Shop Testing of Steam Traps

Repaired, rebuilt, and if practical, even new traps should be steam tested before being installed. A test stand similar to that shown in Figure 5-1 is recommended for activities having a sufficient inventory of traps to warrant shop testing. The test stand should meet the following:

- The test stand height should make connection of pipes easy and the sink should be deep enough to contain splashes.
- The test stand steam supply should provide the different pressures in the activity's steam system. The water supply pressure must be 10 percent higher than the test steam pressure.
- A pressure gage and bimetallic dial thermometer are part of the set-up.
- The open discharge from the test trap faces down in the sink.

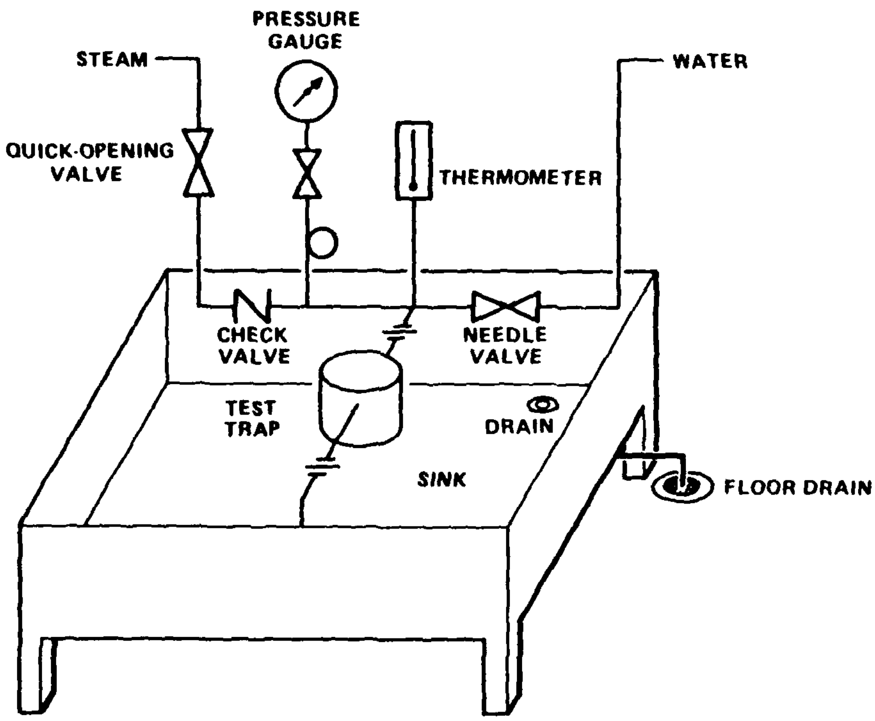

Figure 5-1. Steam Trap Shop Test Stand.

APPENDIX A

STEAM TRAP PRODUCT GUIDE

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7 EAST 12TH ST.
NEW YORK, N. Y. 10003
(212) 741-4485

Armstrong Machine Works
816 Maple St.
Three Rivers, Mich. 49093

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Disc, Series CD40 and CD60 introduced 1964. $54-$199. 1 year - defects, material workmanship.	10-600 psi @ saturated steam temp.; to 2,850 lbs/hr.; 3/8"-1", flanged, screwed, socket weld.	Carbon steel body, hardened stainless steel internal parts, replaceable capsule, built-in strainer available. Steam jacketed control/chamber capsule prevents rapid cycling when trap is exposed to cold, rain or snow. Drip leg and tracing.
Float and thermostatic, Series A, B, J, L, M, LS, MS, introduced 1964. $99-$3,797. 1 year - defects, material, workmanship.	To 450 psig @ 650 degrees F., to 280,000 lbs./hr., 3/4"-3" screwed or socket weld.	Cast iron or forged steel bodies, stainless steel internal parts. Handles large capacities where continuous drainage is essential. Heat exchange equipment with large air volumes.
Inverted bucket, Series 200, 300, 400, 800, 900, 1010, 1810, 1910, 2010, introduced 1930's. $45-$2,500. 1 year (CI, FS bodies) - defects, material, workmanship, 3 years (SS body) - failure due to wear, material, workmanship.	To 3,090 psig @ 900 degrees F.; to 20,000 lbs/hr.; 3/8"-2", flanged, screwed, socket weld.	Cast iron (CI), forged steel (FS), stainless steel (SS) bodies; stainless steel internal parts. Water seal in body prevents live steam leakage; resistant to water hammer; drains condensate at saturation temp. Drip leg, heat exchange, process and tracing.
Thermostatic, Series TTF, introduced 1973. $83-$91. 1 year - defects, material, workmanship.	To 300 psig at saturated steam temp.; to 15,900 lbs./hr. 1/2" - 1", screwed.	Stainless steel body, berillium copper bellows (corrosion-resistant). Discharges condensate at slightly below steam temp. over entire pressure range. Dip leg, small heat exchange equipment, tracing.

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Barnes and Jones Inc.
34 Craft St.
Newtonville, Mass. 02160

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Float and thermostatic, low pressure, introduced 1930's. $49-$322. 1 year - parts, workmanship.	To 15 psi; to 5,700 lbs./hr.; 3/4"-2", female threaded NPT.	Cast iron body, stainless steel or brass internal parts. Air venting is by factory calibrated cage unit thermostat. continuous condensate removal. Low pressure uses.
	Other models: Medium pressure, to 65 psi, to 10,000 lbs./hr., 3/4"-2", $65-$343. High pressure, to 125 psi, to 2,140 lbs./hr., 3/4"-1 1/2", $77-$135.	
Thermostatic, Series GW, introduced 1958. $47. 1 year - parts, workmanship.	To 250 psi; to 5,950 lbs./hr.; 1/2", 3/4" female threaded NPT.	Cast bronze body; activating element - monel bellows, encaged and calibrated. High pressure. Industrial process and tracing.
	Other models: Low pressure, to 25 psig, to 4,100 lbs./hr., 1/2"-1", $22-$45. Medium/high pressure, to 300 psig, to $11,400 lbs./hr., 1/2"-1", $47-$148.	

Bestobell
4545 Pine Timbers
Bldg. 300
Houston, Tex. 77041

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Bimetallic, thermostatic/ thermodynamic, *Deltasphere*, introduced 1981. $96. 3 years - *material*, workmanship. 3 year guarantee- no live steam loss.	To 150 psig, to 4,300 lbs./hr. cold startup; to 800 lbs./hr. hot running load; 1/2", 3/4" screwed.	Stainless steel body and *internals*. Single-bladed element, integral check valve (backpressure protection), fast cold discharge, continuously vents air and non-condensables, resistant to water hammer. Drip leg, process, tracing.
	Other models: To 2,000 psi, to 50,000 lbs./hr. (hot process), 1/2"-3", $74 - $3,500.	

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Clark-Reliance Corp
15901 Industrial Parkway
Cleveland, Ohio 44135

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Floating disc, Series FD and SFD, introduced 1940's. $37-$155. 1 year - material, workmanship.	5-600 psig, to 750 degrees F., to 5,600 lbs./hr. at saturated steam temp., 3/8"-1", screwed.	Stainless steel body and internal parts. Integral strainer and blow-off valve available. Hardened stainless steel disc and seat, replaceable inline. High pressure universal.
Float, Series 80, 600, 700, introduced 1930's. $38-$2,065. 1 year - material, workmanship.	To 1,000 psig; to 750 degrees F.; to 45,000 lbs./hr.; 1/2"-2", flanged, screwed, socket weld.	Cast iron, fabricated steel, forged steel bodies; stainless steel internal parts. For widely variable condensate loads, as in superheated steam systems. Liquid draining operations.
Float and thermostatic, Series FT, introduced 1940's. $40-$793. 1 year - material, workmanship.	To 150 psi; to 12,095 lbs./hr.; 3/4"-2", female NPT.	Cast iron body, bronze bellows, stainless steel float and valve trim. For large air volumes at startup, and varying condensing rates. Industry, hospitals, apartments, schools.
Inverted bucket, introduced 1940's. $27-$1,300. 1 year - material, workmanhip.	To 1,000 psi; to 850 degrees F, to 31,000 lbs./hr.; 1/2"-2" screwed.	Cast iron, forged steel, fabricated steel bodies; stainless steel internal parts. Dual step leverage to increase trap capacity. Any condensate draining, fast removal.
Thermostatic, Series A, AS, S, T, introduced 1930's. $60-$525. 1 year - material, workmanship.	To 300 psi; to 500 degrees F.; to 47,300 lbs./hr.; 1/2"-2", female NPT.	Cast iron, cast steel bodies; monel or phosphorous bronze bellows. Integral strainer available on Series AS. Process, tracing, low pressure.

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Cochrane Environmental Systems Div.
Crane Co.
P.O. Box 191
King of Prussia, Pa. 19406

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Float, Type A Drainer, introduced 1930's. $780-$1,500. 1 year - material, *performance, workmanship.*	To 60 psig; to 300 degrees F.; to 120,000 lbs./hr.; 1"-3", flanged, screwed.	Cast iron body, bronze internal parts. Modulating valve controls rate of discharge on continuous basis. Manual open/close device. Draining heat exchange equipment used with steam heating.
	Other models: Float, to 200 psig, to 750 degrees F., to 165,000 lbs./hr., $1,500-$3,000.	

Engineering Resources Inc.
International Tower Building
8550 W. Bryn Mawr Ave.
Chicago, Ill. 60631

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Fixed orifice, Steamgard introduced 1980. $61-$270. 3 years - material, workmanship. 1 *year guarantee - performance.*	To 2,000 psig superheated steam to 1,125 degrees F.; to 100,000 lbs./hr.; 1/2"-1", NPT, socket weld.	Bronze, stainless steel alloy bodies, stainless steel internal parts. Continuous condensate removal, built-in strainer available, replaces mechanical traps, no moving parts. Drip leg, tracing, process, heating, chiller, absorption, heat exchanger.

Flexitallic Gasket Co. Inc.
151 Heller Place
Bellmawr, N. J. 08031

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Thermostatic, Flexitrap, introduced April 1982. $120. 3 years - material, workmanship.	To 600 *psig*; to 500 degrees *F.* saturated, to 900 degrees F. superheated; 5-6,000 lbs./hr.; 1/2", 3/4", NPT.	Forged steel body and cover, stainless steel internal parts. Dual range - drain orifice and thermostatically operated valve. Side inlet, bottom outlet. All condensate removal including warmup *loads.*

Gestra Inc.
215 Union St.
Hackensack, N. J. 07601

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Bimetallic, thermostatic, BK, introduced 1950's. $77-$1,200. 1-3 years - labor, parts, workmanship.	To 3,120 psi; to 15,000 lbs./hr.; 1/2"-2", ANSI flange, NPT, butt weld, socket weld.	Forged steel body, stainless steel internal parts. Built-in strainer and check valve, rapid startup, large cold water capacity. Drip leg, process, high pressure.
Thermostatic-membrane, MK, introduced 1970. $38-$1,500. 1-3 years - labor, parts, workmanship.	To 320 psi; to 400,000 lbs./hr.; 1/4"-4", ANSI flange, NPT, butt weld, socket weld.	Forged steel, stainless steel bodies; hastelloy, stainless steel internal parts. Evaporation thermostatic element, built-in strainer. Ball check valve in some models. Optional - blow-off valves. Drip leg, process, tracing.

Hoffman Speciality - ITT
1700 West 10th St.
Indianapolis, Ind. 46222

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Disc, Series 600, introduced 1979. $55-$129. 18 months - parts, workmanship.	To 600 psi; to 750 degrees F.; to 2,850 lbs./hr.; 3/8"-1", screwed.	Stainless steel body and internals. Drip leg, tracing.
Float and thermostatic, and float. Series 50 and 500, introduced 1926. $60-$250. 18 months - parts, workmanship.	To 125 psi; to 353 degrees F.; to 12,095 lbs./hr.; 3/4"-2", screwed.	Semi-steel body, stainless steel internal parts. Handles large air quantities with thermostatic air by-pass. Drip leg, process, schools, hospitals, office bldgs., apts.

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TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Inverted bucket, Series 600, introduced 1950. $48-$242. 18 months - parts, workmanship.	To 250 psi; to 406 degrees F.; to 11,500 lbs./hr.; 1/2"-1 1/2", screwed.	Semi-steel body, stainless steel *internal parts*. Build-in strainer on model 601AS. Drip leg.
Thermostatic, Series 8, 9, introduced 1920's; Series 17, introduced 1945. $22-$105. 18 months - parts, workmanship.	To 125 psi; to 353 degrees F.; to 1,250 lbs./hr.; 1/2"-1", screwed	Bronze, brass bodies; non-corrosive alloys, stainless steel internal parts. Renewable bellows, seats, thermostats. Angle, straightway, swivel patterns. Steam heat radiators.

Honeywell Braukmann
700 Ellicott St.
Batavia, N. Y. 14020

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Thermostatic bellows, ST510A, introduced 1975. $35-$49. 1 year - parts, workmanship.	To 140 psi; to 360 degrees F.; to 8,300 lbs./hr.; 1/2"-1", male threaded union X female threaded.	Brass body, cap; phosphor bronze bellows; stainless steel seat, seat head. Removeable seat, built-in screen. Industrial steam heating.

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Nicholson Div.
Datron Systems Inc.
12 Oregon St.
Wilkes-Barre, Pa. 18702

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Float-actuated, mechanical weight-operated; B 1/2/3, C, JR, WO; introduced 1900's. $265-$7,000. 1 year - material, workmanship.	2-1,500 psig; 0-1,100 degrees F.; 2-200,000 lbs./hr.; 1/2"-2" flange, NPT.	Cast iron, cast steel bodies; stainless steel internal parts. High pressure, high capacity.
Inverted bucket, Series B, BS, introduced 1950. $52-$1,237. 1 year - material, workmanship.	To 600 psig; to 750 degrees F.; to 44,000 lbs./hr.; 1/2"-2 1/2", NPT	Series B-cast iron body, low pressure. BS-steel body, high pressure. Stainless steel internal parts. External valve assembly - repairable in-line. Reversible and self-centering valve. Self-cleaning vent. Process steam.
Thermodynamic disc N600, introduced 1967. $50 - $195. 1 year material, workmanship.	2-600 psig; to 750 degrees F.; to 6,400 lbs./hr.; 3/8" - 1"., NPT.	Forged steel body, stainless steel internal parts. Renewable inline; integral blowdown and strainer; steam-jacketed; freezeproof in specific positions. Drip leg, tracing.
Thermostatic bellows, N-302, introduced 1981. $156-$163. 3 years - material, workmanship.	To 300 psig; to 500 degrees F.; to 502 lbs./hr.; 1/2", 3/4", NPT, socket weld.	Forged steel body, stainless steel internal parts. Integral blowdown and strainer; welded stainless steel bellows, resistant to hydaulic and thermal shock; fail open; freezeproof vertically. Light process, tracing.
	Other models: For heating, process, tracing - to 300 psig, 1/2"-2", $50-$460.	

Ogontz Controls Corp.
141 Terwood Road
Willow Grove, PA 19090

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Temperature actuated, CTV, introduced 1977. $85. 18 months - material, workmanship.	To 300 psi; to 4,300 lbs./hr.; 1/2"-NPT	Stainless steel body; brass, stainless steel internal parts. Condensate temperature valve cools condensate below saturation temp., dirt resistant plug and seat, temp. sensitive 35 degrees-240 degrees f. Drip legs, tracing.

Process Technology of PA Inc.
445 Bethelehem Pike
Colman, Pa. 18915

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Bimetallic, thermostatic Series 46, introduced April 1982. $36-$38. 1 year - function, material, parts, workmanship.	To 200 psi; to 750 degrees F.; to 400 lbs./hr.; 3/8"-3/4", NPT.	Stainless steel body, internal parts. Bimetallic (8 plates in series); modulating discharge; built-in check valve; discharge temp. 40 degrees-60 degrees below saturation temp. Drip leg, tracing.
Bimetallic, thermostatic, disc Series 44, introduced April 1982. $36-$38. 1 year - function, material, parts, workmanship.	To 200 psig; to 220 degrees F.; to 400 lbs./hr.; 3/8"-3/4", NPT.	Stainless steel body, internal parts. Subcooling regardless of pressure (discharges condensate below saturation temp.) Curved bimetallic disc, on/off discharge, freeze-proof, self-draining. Tracing.
Thermostatic, bellows, Series 40, introduced April 1982. $36-$38. 1 year - function, material, parts, workmanship.	To 200 psi; to 400 degrees F.; to 4,000 lbs./hr.; 3/8"-3/4", NPT.	Stainless steel body, internal parts. Closely follows saturation temp. curve of steam; freeze-proof; self-draining; compact. Drip leg, light-medium load process, tracing.

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Sarco Co.
Subsidiary of White
Consolidated Industries
1951 26th St., S.W.
Allentown, Pa. 18105

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Float and thermostatic, FT-125, introduced 1965. $92-$318. 1 year - material, workmanship.	To 125 psi; to 353 degrees F.; to 6,600 lbs./hr./ 3/4"-2" screwed.	Cast iron body, stainless steel internal parts. Modulating discharge; continuous discharge of condensate at steam temp. Independent thermostatic air vent for high air venting capacity. Process.
	Other models: 15-250 psi, to 68,000 lbs./hr., 1/2"-2 1/2", $63-$1,100.	
Thermostatic, T300 introduced 1982. $97. 1 year - material, workmanship.	To 300 psi; to 421 degrees F.; to 580 lbs./hr./ 1/2" screwed, socket weld.	Forged steel body, stainless steel internal parts. Welded stainless steel bellows, maintainable in-line, freeze-proof, self-adjusts to any pressure. Steam main drip legs.
	Other models: Cast iron body, 25-250 psi, to 33,000 lbs./hr., 1/2"-2", $25-$388.	
Thermodynamic, TD-52L introduced 1960. $45-$120. 1 year - material, workmanship.	To 600 psi; to 800 degrees F.; to 1,250 lbs./hr.; 3/8"-1" screwed, socket weld.	Stainless steel body, internal parts. Small size, 1 moving part. *Optional-built-in strainer.* Drip leg, process, tracing.
	Other types: bimetallic, SCB-to 300 psi; to 390 lbs./hr.; 1/2", NPT, socket weld; $99. Liquid expansion, Typc C Thermoton - to 300 psi; to 2,400 lbs./hr.; 3/4", NPT; $113. Inverted bucket, Type B-15-250 psi; to 19,400 lbs./hr.; 1/2"-2", NPT, $45-$342.	

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TLV Co. Ltd.
Toyoda America Inc.
Suite 5067
1 World Trade Center
New York, N. Y. 10048

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Bimetallic, thermostatic, RT1, introduced 1974. $60-$67. 3 years - materials, parts.	To 228 psi; to 428 degrees F.; to 920 lbs./hr.; 1/2"-1", NPT.	Malleable cast iron body; stainless steel internals, strainer. 2 position stainless steel bimetallic element, discharge temp. 100 degrees F. Radiator traps, non-freeze valves, air vents.
Float and thermostatic, free-floating ball, Series J, JH, introduced 1974. J-$70-$2,000. JH-$700-$5,000. 3 years - materials, parts.	To 900 psi; to 800 degrees F.; to 90,000 lbs./hr.; 1/2"-4", flange, NPT. Other models: Drip leg, tracing, SST - all stainless steel, to 300 psi, 800 degrees F., 1/2"-3/4", $80.	J-Malleable cast iron body. JH-cast steel body. J and JH-stainless steel internal parts, continuous discharge. Drip leg, process.
Inverted bucket, free ball bucket, UFO, introduced 1981. $70-$1,000. 3 years - materials, parts.	To 228 psi; to 428 degrees F.; to 13,500 lbs./hr.; 1/2"-4", flange, screwed NPT.	Malleable cast iron body; stainless steel internal parts, built-in strainer. Linkage free - 1 moving part. Cylinder drives, drip leg, tracing.
Thermostatic, thermodynamic, disc, introduced 1966. $47-$3,000. 3 years - materials, parts.	To 3,700 psi; to 1,020 degrees F.; to 1,400 lbs./hr.; 1/4"-1", butt weld, flange, screwed, socket weld.	Stainless steel strainers. Integral air venting on some models. High pressure and temperature.

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Velan Steam Trap Corp.
Beekman Town Road
P.O. Box 220
Plattsburg, N. Y. 12901

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Bimetallic, float and thermostatic, Series MFT, introduced 1955. $40-$300. 1-3 years - materials, workmanship.	To 200 psi; to 450 degrees F.; to 25,000 lbs./hr.; 3/8"-3", flanged, screwed.	Cast iron body, stainless steel internal parts. Stellite-faced valve seat, automatic air venting, integral check valve and strainer. Fast condensate discharge, process.
Bimetallic, thermostatic, introduced 1948. $35-$1,000. 1-3 years - materials, workmanship.	5-2,500 psi; to 1,050 degrees F.; to 300,000 lbs./hr.; 3/8"-3", butt weld, flange, screwed, socket weld.	Carbon steel, cast iron, chrome-moly steel, stainless steel bodies. Bimetallic, graduated closing force follows steam curve. Stellite-faced valve seat, integral check valve and strainer, automatic air venting. Drip leg, process, tracing; petroleum, petrochemical, power industries.
Thermodynamic, Type VT, introduced 1965. $40-$100. 1 year - material, workmanship.	5-600 psi; to 850 degrees F.; to 3,000 lbs./hr.; to 3/8"-1", butt weld, flanged, screwed, socket weld.	Forged carbon steel body, stainless steel internal parts. Repaceable valve seat, integral strainer. General steam trapping use.

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Yarway Corp.
Norriston Road
Blue Bell, PA 19422

TYPE, MODEL COST AND WARRANTY	MODEL RANGES AND CONNECTIONS	FUNCTIONS, FEATURES AND APPLICATIONS
Inverted bucket, Unibody 790/795, introduced 1981. $88-$177. 1 year - material, workmanship.	To 400 psi; to 750 degrees F.; to 800 lbs./hr.; 1/2"-3/4", screwed, socket weld.	Chrom-moly body, stainless steel internal parts. Integral strainer available, in-line renewable, freeze resistant. Drip leg, process, tracing.
	Other models: Series 600, non-renewable in-line, to 400 psi, to 800 lbs./hr., 1/2"-3/4", screwed, $61-$68.	
Thermodynamic, Unibody 710/720, introduced 1975. $75-$198. 3 years - material, workmanship.	To 600 psi; to 750 degrees F.; to 1,400 lbs./hr.; 3/8"-1", screwed, socket weld.	Chrom-moly body, stainless steel internal parts. Accepts capsules of thermostatic, thermodynamic, mechanical traps. Integral strainer and blowdown valve model available. Drip leg, tracing.
	Other models: Unibody disc, piston, orifice - for drip leg, tracing, process; to 600 psi, to 5,000 lbs./hr., 3/8"-1", screwed, $75-$390	
Thermostatic, Series 151, introduced 1970's. $86-$150. 1 year - material, workmanship.	To 300 psi; to 500 degrees F. continuous duty; to 12,000 lbs./hr.; 1/2"-3/4", screwed, socket weld.	Carbon steel body; stainless steel cover, internal parts (replaceable in-line). Balance pressure bellows, integral strainer. High and low range of flow rates for heavy start-up and smaller running loads. Process, special steam line applications (end of main, steam separator).
	Other models: Unibody 750/760, for drip leg, tracing; to 600 psi, 1,000 lbs./hr., 1/2"-1", $116-$282. Other types: Bimetallic, thermostatic, for drip leg, process, tracing; to 2,150 psi, to over 300,000 lbs./hr. of hot condensate, 1/4"-4", flange, socket weld, screwed, $50-$2,400.	

NOTES:

The introduction dates above are for the earliest models in the series; newer models may have been introduced later. The "Model Ranges and Connections" column lists the maximum pressure rating (psi), maximum temperature rating (degrees F.), maximum condensate capacity (lbs./hr.), connection sizes (inches), and connection types available in the model series.

NOTES (continued):

The maximum ratings and capacity of a steam trap will depend on the operating pressure and temperature, and trap size, that the individual trap is designed for. The cost of the listed models is the suggested list price to the end-user. Installation is generally done by the user or a contractor.

The above models are a representative sample from a range of manufacturers. Space limitations prevent all companies and models from being listed. EUN takes no responsibility for misapplication of products since data is based on manufacturers' statements. This Product Guide is copyright Energy User News, February 28, 1983, and is reproduced with permission.

APPENDIX B

MANUFACTURERS OF SOUND DETECTION EQUIPMENT

1. UE Systems, Inc.
   1995 Broadway
   New York, NY 10023

2. TECHSONICS
   P.O. Box 251
   El Prado, NM 87529

3. TLV Company
   140 E. Franklin Ave.
   Collinswood, NJ 08108

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